MARCH 7, 1960
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Chemical Engineering

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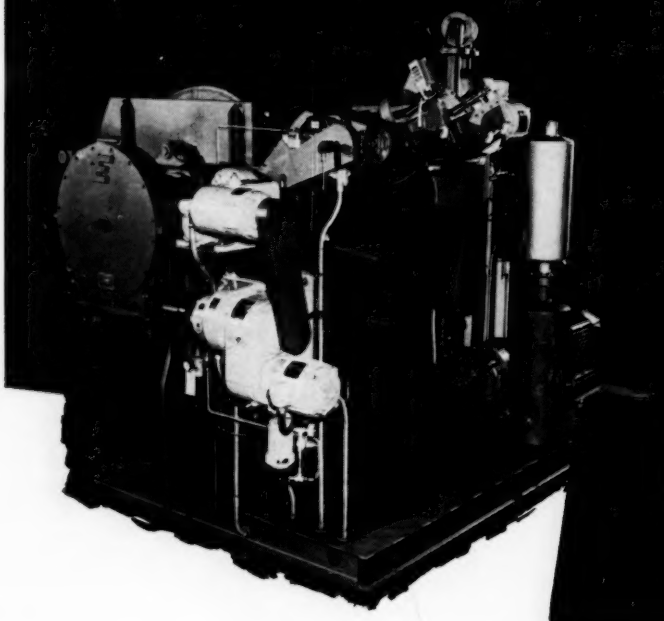
TECHNOLOGY DEPARTMENT

RELIABLE METHODS FOR PREDICTING CAPITAL COSTS

Can Automation Like This Cut Costs For You?



EIMCO
AUTOMATED
Precoat Filter

When a large chemical company wanted a filter with automated controls, Eimco built the automated platform precoat filter station shown above.

When slurry level in the tank rises, drum speed is automatically increased to compensate for either slower filtration rate or higher feed rate. When level falls, drum speed is slowed.

Separate level controls in the receiver stop the filtrate pump if filtrate level falls too low. An alarm sounds if it rises too high. If slurry continues to rise above alarm level the filter is stopped.

Drum drive and scraper advance are interconnected, so that when drum speed varies, the scraper advance is automatically adjusted.

In filtration, Eimco has engineered many custom-built filters for highly specialized applications.

In developing new and profitable solutions to filtration problems, Eimco engineers are guided by this valuable backlog of experience . . . and by the results of Eimco's research into the science of filtration.

In addition to a complete line of vacuum and pressure filters, Eimco builds all gravity and flotation equipment for liquid-solids separation.

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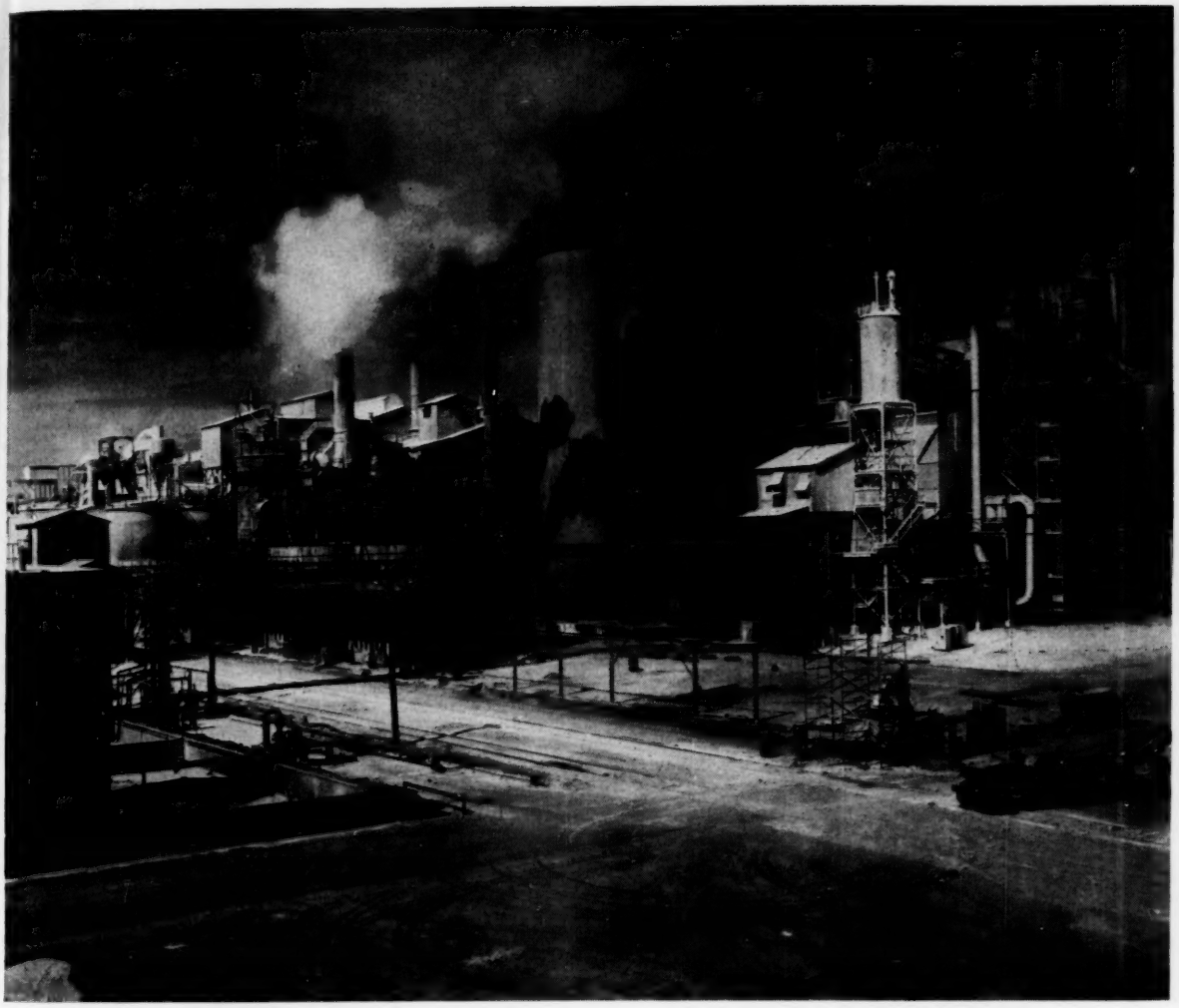

Rocks brewed in acid build bumper crops

IN big tanks at this plant, hot acid dissolves phosphate from ground-up rock, much like hot coffee dissolves sugar. This liquid is then drained away to make fertilizer. Ordinary metal tanks couldn't be used to hold the swirling mixture because rock would wear out the metal, acid would eat holes in it. They needed tanks tough enough to resist both acid and abrasion.

B.F.Goodrich engineers recommended lining steel tanks with special rubber compounds attached by the B.F.Goodrich "Unilock" process. The rubber lining is locked to the metal so strongly and tightly that it practically becomes a part of it. A square inch of it can stand a 500 pound tug without tearing loose. High temperatures don't affect it. Even if the acidproof rubber is punctured, the bond confines the damage to a small area where it can easily be repaired.

Thirty-five big tanks were rubber-lined by the B.F.Goodrich process—eleven of them so large they had to be lined at the plant. That was seven years ago. Since then the tanks have been in operation 24 hours a day, seven days a week, look good for many more years of service.

When you order tank linings, the true cost is the price divided by the years of satisfactory service. On that basis, your cost will be the lowest when you specify B.F.Goodrich. In the past 36 years, B.F.Goodrich has rubber-lined thousands of tanks to handle acids and other corrosives. Some are still in use; others lasted 15 to 20 years. Not one ever failed to end costly shutdowns for repairs. *B.F.Goodrich Industrial Products Co., Dept. M-807, Akron 18, Ohio, or Tuscaloosa, Alabama.*

B.F.Goodrich

TANK LININGS

LOOK INTO THIS BIRD

Pictured is an 18" long scale model with transparent bowl so you can look inside and see the screw conveyor rotating with the bowl but at slightly lower speed to effect continuous discharge of thoroughly deliquored solids. Separating forces range 30 to 3000 gs.

Whenever you have to deal with —

thin feed slurries — as little as 2 or 3% solids

thick feed slurries — as much as 50 to 60% solids

small volumes — as low as 0.25 cu. ft. per minute

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March 7, 1960 **Chemical Engineering** Vol. 67 No. 5

CHEMICAL TECHNOLOGY FOR PROFIT-MINDED ENGINEERS

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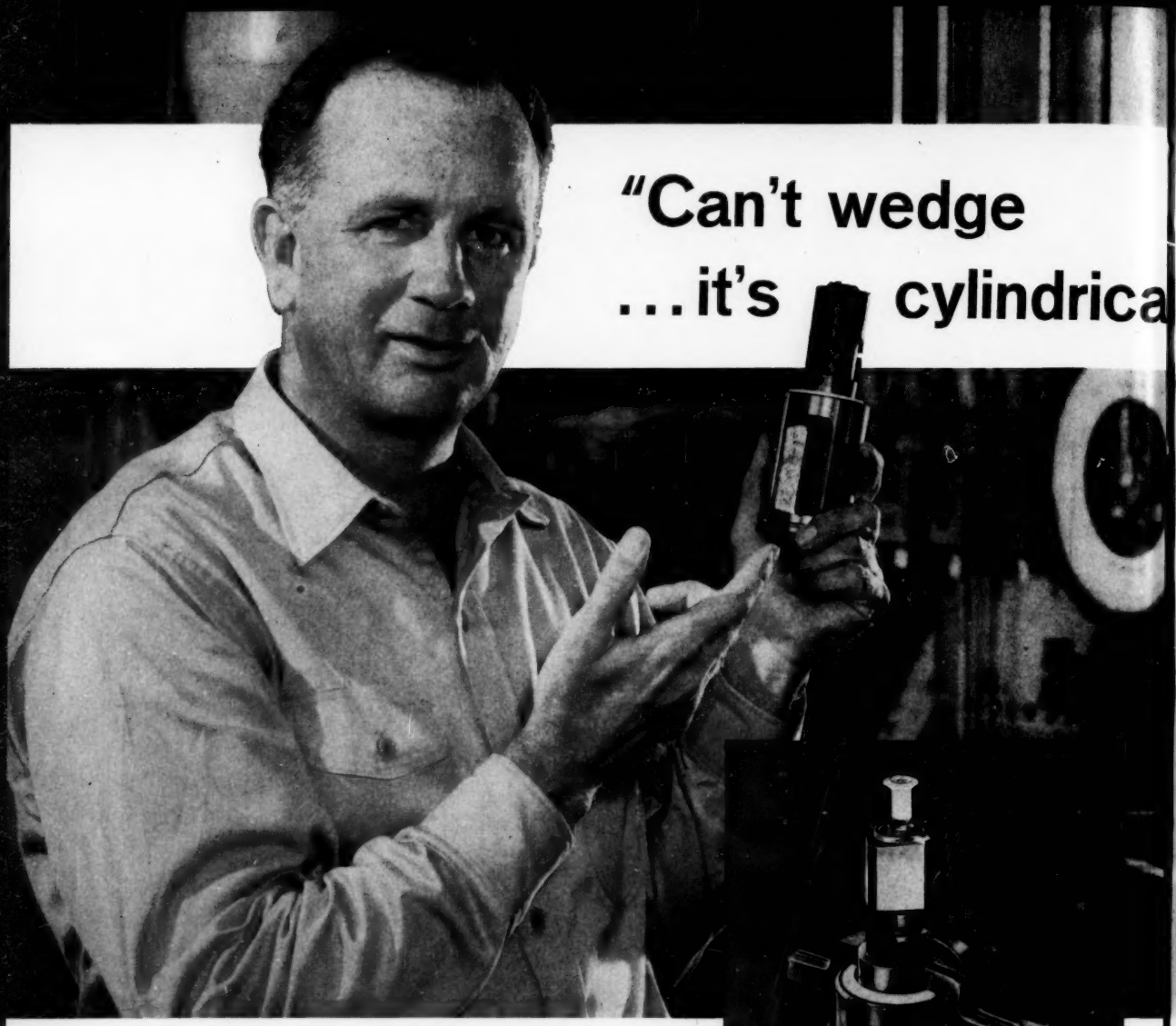

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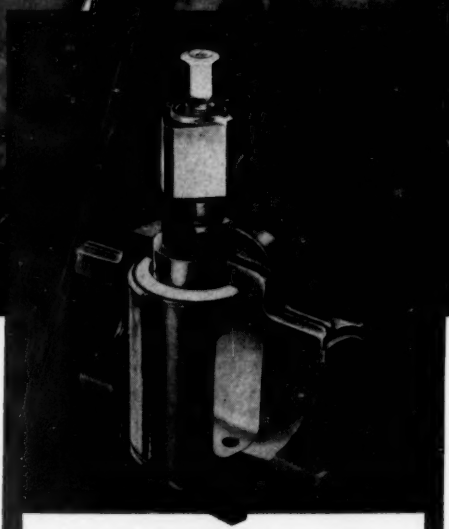

ACF semi-steel lubricated Plug Valves are available in rectangular, round, diamond, and V ports; venturi, multiport and steam-jacketed models.

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Chemical Engineering

March 7, 1960

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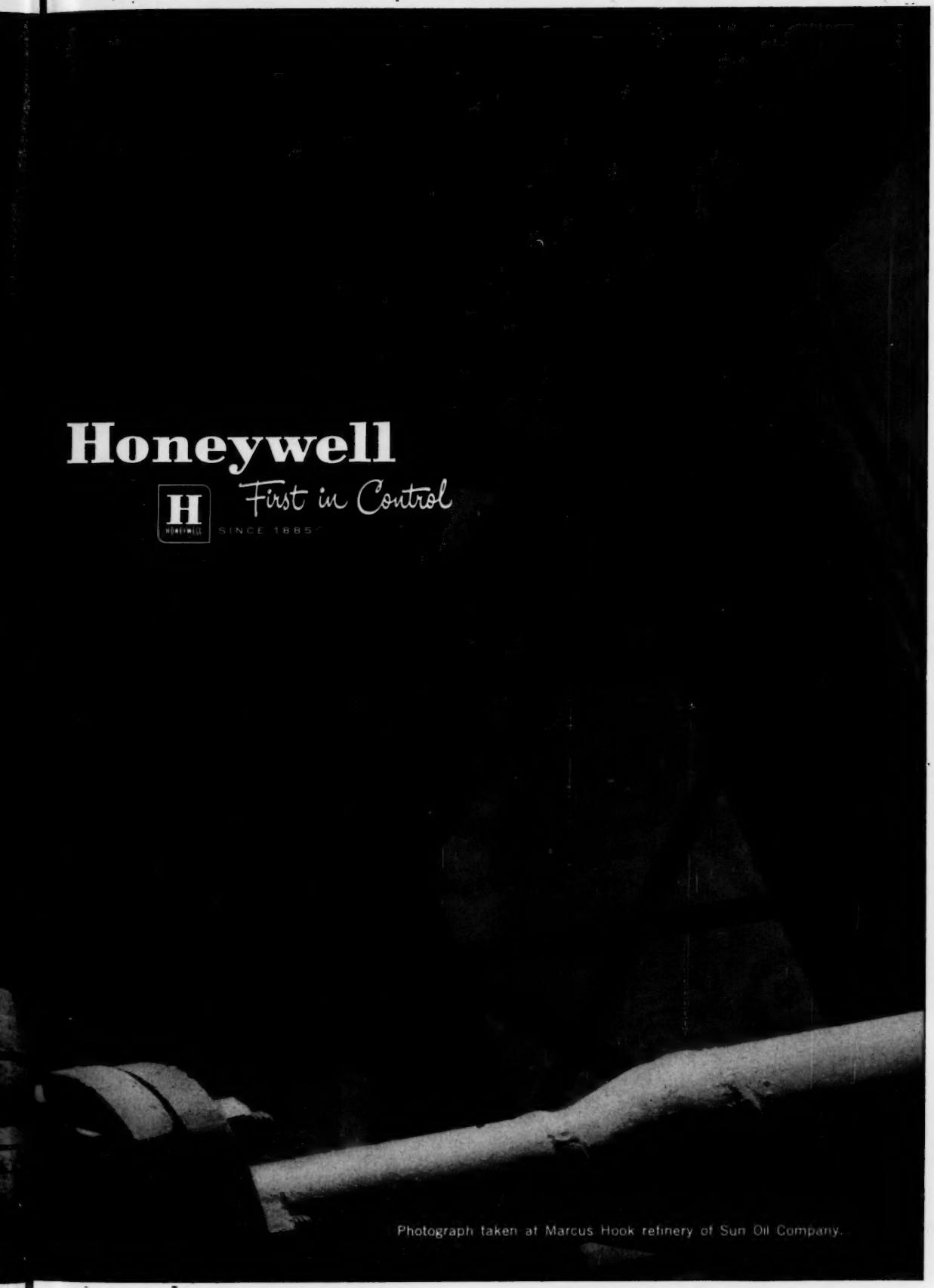


Photograph taken at Marcus Hook refinery of Sun Oil Company.

How lasting quality bui
Heat Exchange

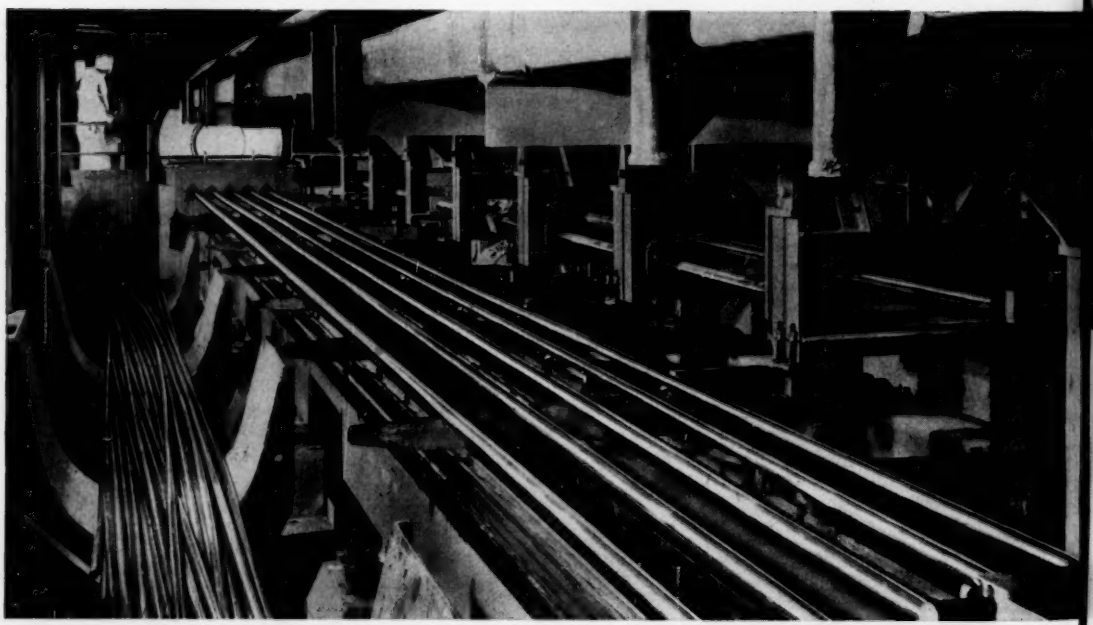
Drawing is a basic tube fabrication operation that transforms newly extruded tubes into standard and special size tubes for various applications. Phelps Dodge uses the cold-drawing process, a method in which precise control and master craftsmanship are combined to produce tubes that meet the most exacting specifications.

The cold-drawing method is used throughout, because it assures maximum tube quality through carefully coordinated operations on a drawbench where simple axial tension is applied.

After initial lubrication the tubes are brought to the drawbench. Each tube is slipped over a mandrel and hollow supporting rod, then drawn through a die and over the mandrel to form a tube of the desired diameter and wall thickness. Continuous lubrication is applied to each tube during this operation to control surface quality and minimize heat generated during the processing cycle.

Dual-gauge tubing is the result of a modified drawing operation which was developed by Phelps Dodge. In this operation, a heavier wall thickness is provided at one or more points of the tube length to compensate for thinning of the outer portions of return bends. In this manner, uniform thickness is retained where ordinary tubes thin out.

Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.

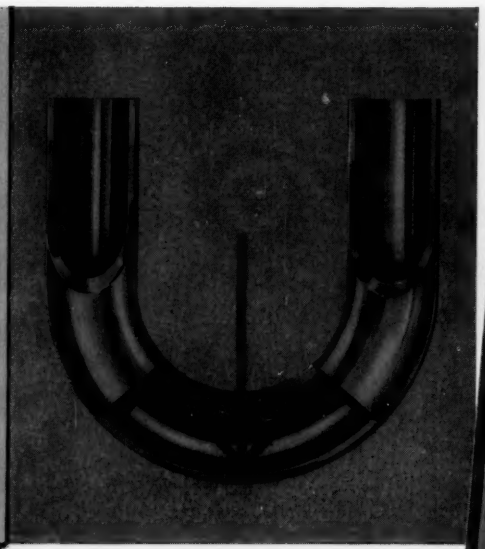


In automated drawing operation at new Phelps Dodge mill, tubes are pulled through reducing dies into smaller diameters and longer lengths.

built into Phelps Dodge end Condenser Tubes...

3 DRAWING

(THIRD OF A FIVE-PART SERIES)



Cutaway of Dual-gauge tube; note how extra metal provides additional safety factor by retaining uniform wall thickness at return bend.

Pointing one end of an extended copper shell, a preliminary step in the drawing process.

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NEW FLUOREL® 2141

BRAND ELASTOMER

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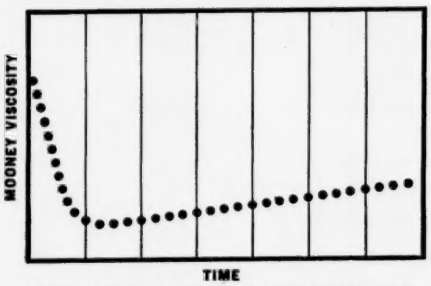
advance in elastomers...

Its Mooney Scorch Rating is ideal for the fluorinated rubber processor because it makes possible fast, more economical cures with fewer defects, less scrap, fewer rejected parts. Material can be reprocessed with greater safety.

A SIGNIFICANT BREAKTHROUGH in elastomer processing has been made possible by 3M Research through development of its new FLUOREL 2141 Elastomer.

This remarkable new product has a Mooney Scorch Rating outstanding among fluorinated elastomers. The range permits the rubber processor to achieve fast, more economical



Mooney Scorch Curve for FLUOREL 2141 Brand Elastomer.

cures with fewer defects, less scrap and fewer rejected parts. The inherent safety of FLUOREL Elastomer 2141 allows repeated reprocessing to produce high quality parts that meet military specifications or other critical end uses.

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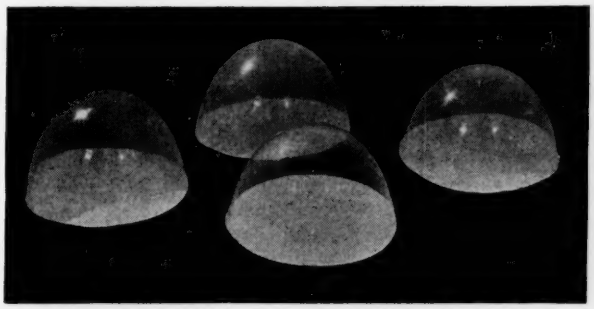
Examine, too, your present rubber products with an eye toward increasing their life and quality through use of FLUOREL 2141 Elastomer. For complete data, write today on your company letterhead to: 3M Chemical Division, Dept. KAL-30, St. Paul 6, Minn.

KEL-F® Brand Plastic guards aircraft radar



KEL-F DISPERSION FILM was chosen for these radome covers by Hughes Aircraft for its fine thermal-insulating qualities, zero-moisture absorption and excellent chemical stability. Under actual operating conditions, temperatures inside the radome were reduced as much as 170° F., permitting trouble-free, efficient operation of the electronic system enclosed. In addition, the cover offers maximum resistance to moisture and erosion. These covers were made by the National Glaco Chemical Corporation, a subsidiary of Ekco Products Co., Whittier, Calif.

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CHEMICAL DIVISION

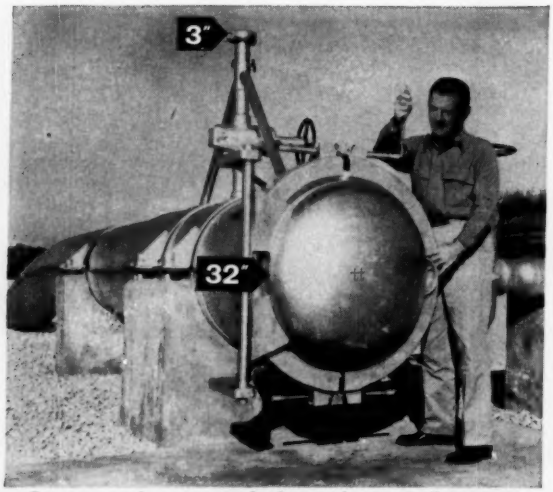
MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

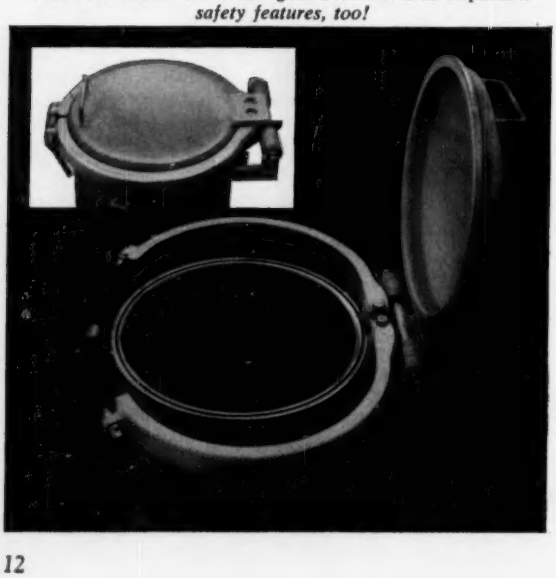
3M COMPANY

NEW...FROM TUBE

an improved hinged closure for pipe lines, piping and process equipment



One man, using any standard wrench, can easily open or close the TUBE-TURN *Hinged Closure. Has important safety features, too!*



Tube Turns announces a new line of hinged closures with important advantages for pipe lines, piping and process equipment wherever frequent access is required or where the use of blind flanges would be cumbersome and time consuming. Proved in scores of applications by major companies, the unique TUBE-TURN* Hinged Closure provides these benefits:

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Saves on maintenance. Oil resistant, self-energizing static "O" ring provides seal. Does not move when cover is opened or closed. No rubbing or chafing to shorten seal life.

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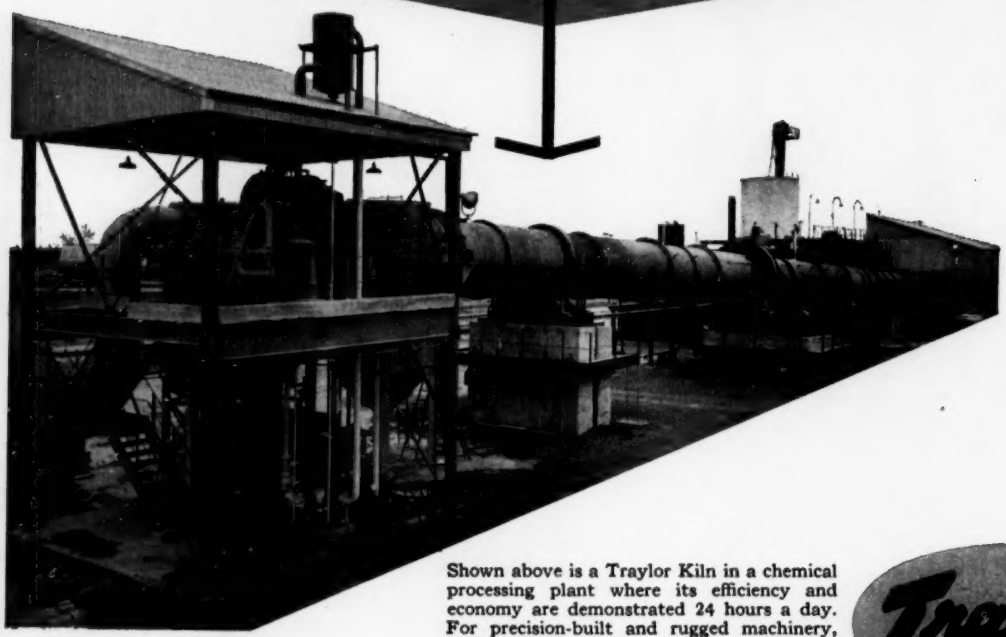

Shown above is a Traylor Kiln in a chemical processing plant where its efficiency and economy are demonstrated 24 hours a day. For precision-built and rugged machinery, call on Traylor Engineers today. Write for Bulletin No. 1115 for more on Traylor Kilns.

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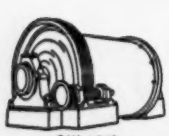

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PRIMARY GYRATORY CRUSHERS

JAW CRUSHERS

SECONDARY GYRATORY CRUSHERS

Buying acid at small-quantity prices was eating away profits at this small New York State plant. Besides, the carboys were awkward to handle and store. And there was always the danger of one breaking or spilling and injuring a man. Then the G.T.M.—Goodyear Technical Man—made a suggestion: install a 2,000-gallon PLIOWELD lined tank that will store a tank-truck-load of acid at a time. Result: this firm is saving $1810 a year on muriatic acid costs alone—more than enough to pay for the lined-tank installation in the first two years. And that's not even counting the elimination of broken-carboy costs or the increased convenience of drawing the acid from a tap as needed.

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- Tank Barges
- Railroad Tank Cars
- Fans—blades, wheels, housings
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- Furnace Hoods and Ducts
- Screens and Trays
- Air Purifiers
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- Troughs and Chutes
- Continuous Vacuum Filters
- Pumps
- Filter Frames
- Miscellaneous Fabricated Items

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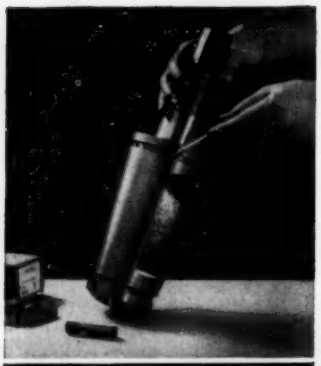
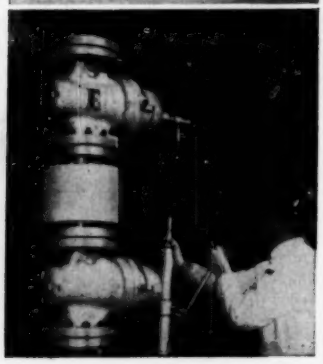
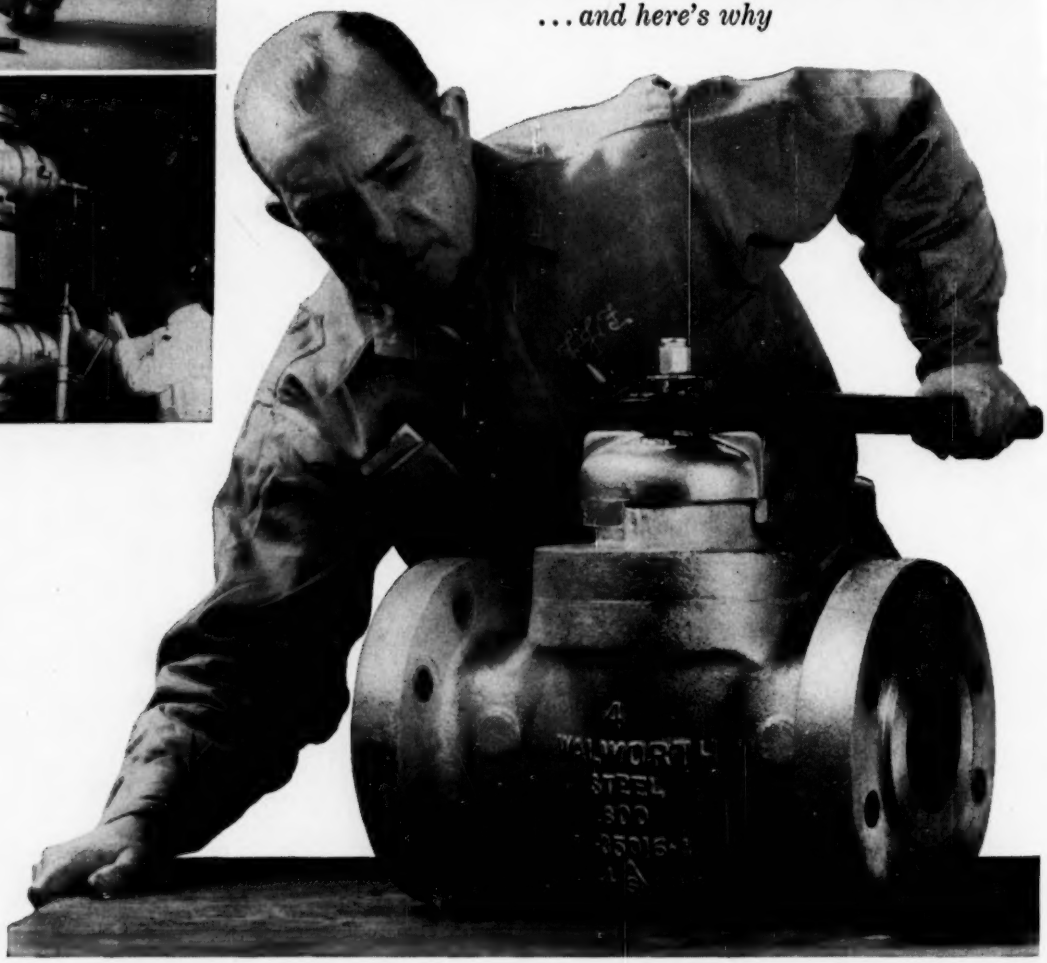




the **WALWORTH CUSTOMER**
wants a quick operating, sure, tight valve. He chooses a

WALWORTH
LUBRICATED PLUG VALVE
... and here's why



When the Walworth Customer has to decide on a valve that will close fast and easily, he wants to know HOW fast... HOW easily. Tight closure? Of course. But can the valve be serviced under pressure? Yes. Still, he tries one himself.

In the Walworth Lubricated Plug Valve he finds 100% tight closure because it is lubricant-sealed against leakage. He finds it opens or closes with a quarter turn. Then, and only then, he's ready to buy. If that's the way you like to buy valves, we want you, too, for a Walworth Customer. For details on all types and ratings of Walworth Lubricated Plug Valves, ask your Walworth Distributor.

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COILMOUNT for medium-duty service. For applications up to 80 TPH of 100-pounds-per-cubic-foot material. Widths of 10 and 20 in. with 6-in. deep troughs. Available from stock in completely assembled 5- and 10-foot sections.

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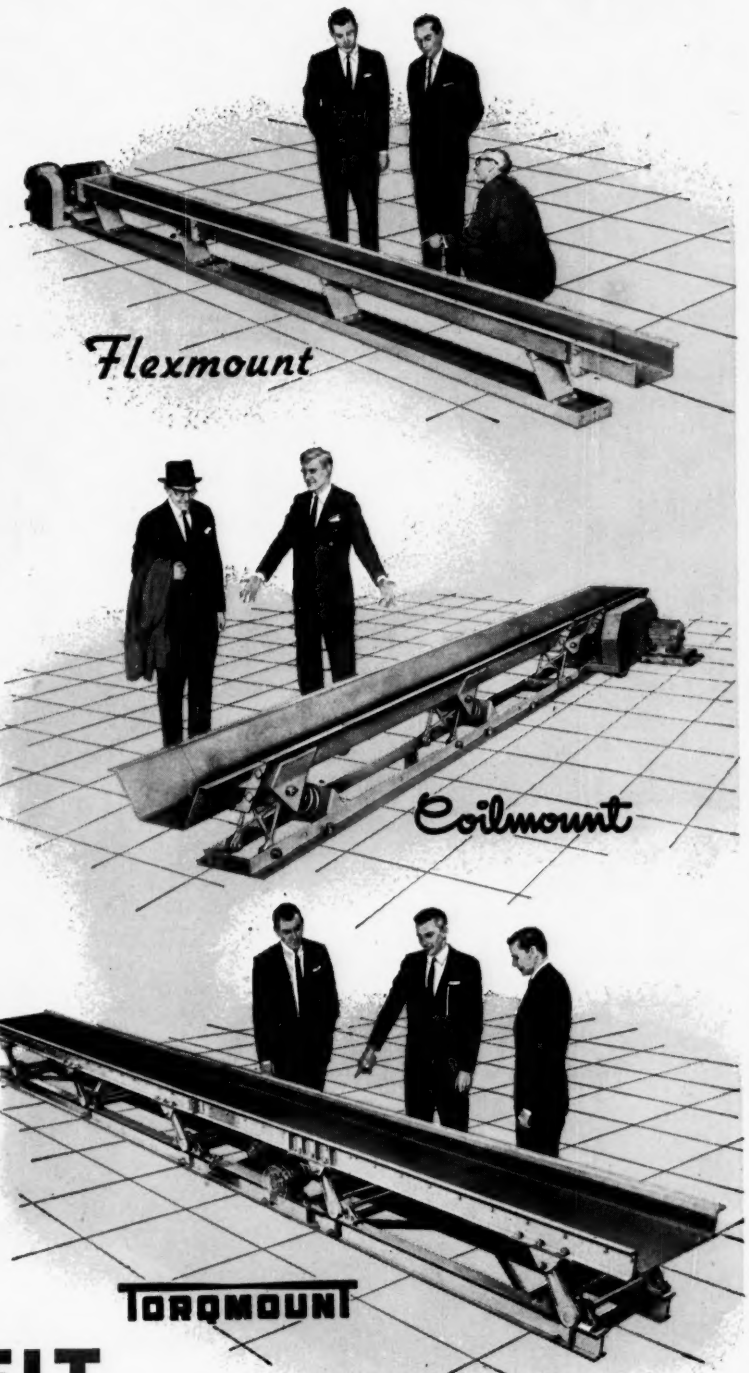

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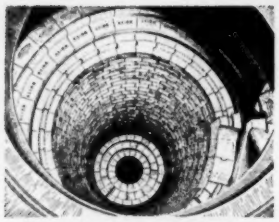
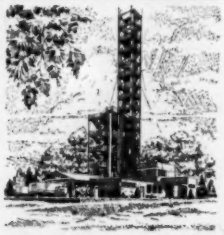
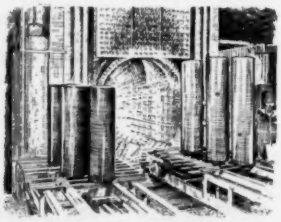


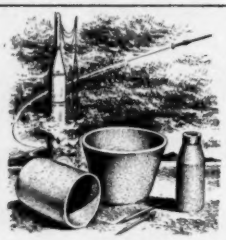
Pebble Heater Linings and Pebbles



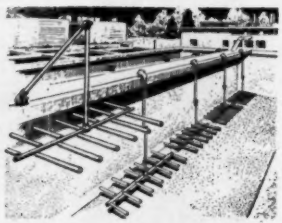
Chemical Reactor Linings



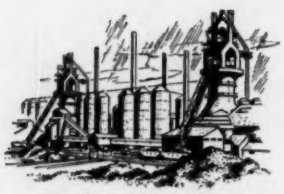
Muffle Plates and Kiln Shapes



Missile and Rocket Ceramics



Porous Media for Sewage Systems



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Working with today's imaginative design engineers, Norton Company's "Men with the Facts" are creating exciting new concepts in products and processes. Utilizing the wide variety of physical, chemical and electrical properties of Norton Refractory Materials, they help to solve design problems in products ranging from lightning arrestors to rockets . . . in processes as different as filtration and gas synthesis.

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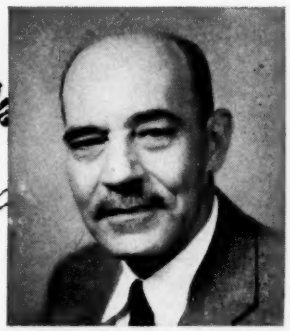
NORTON Refractories and the NORTON Man



Curt Weissinger, typical of "Norton Men with the Facts," designed special refractory shapes for a pebble heater to withstand super high temperatures and corrosive conditions. He's also been responsible for successful applications of refractories to reactors, enameling kilns, billet furnaces, missiles and rockets, sewage systems, and other products and processes. Now Supervisor of Norton Refractories Technical Service, Curt has been with the Company for 29 years . . . he's ready to help you in the proper application of Norton Refractory Materials.

Often MAGNORITE* magnesium oxide solves a problem with its high purity and excellent thermal conduction and high electrical resistance. Or, the immunity to oxidation and reduction of zirconium oxide, one of today's highest melting point oxides available in tonnage quantities, may be invaluable.

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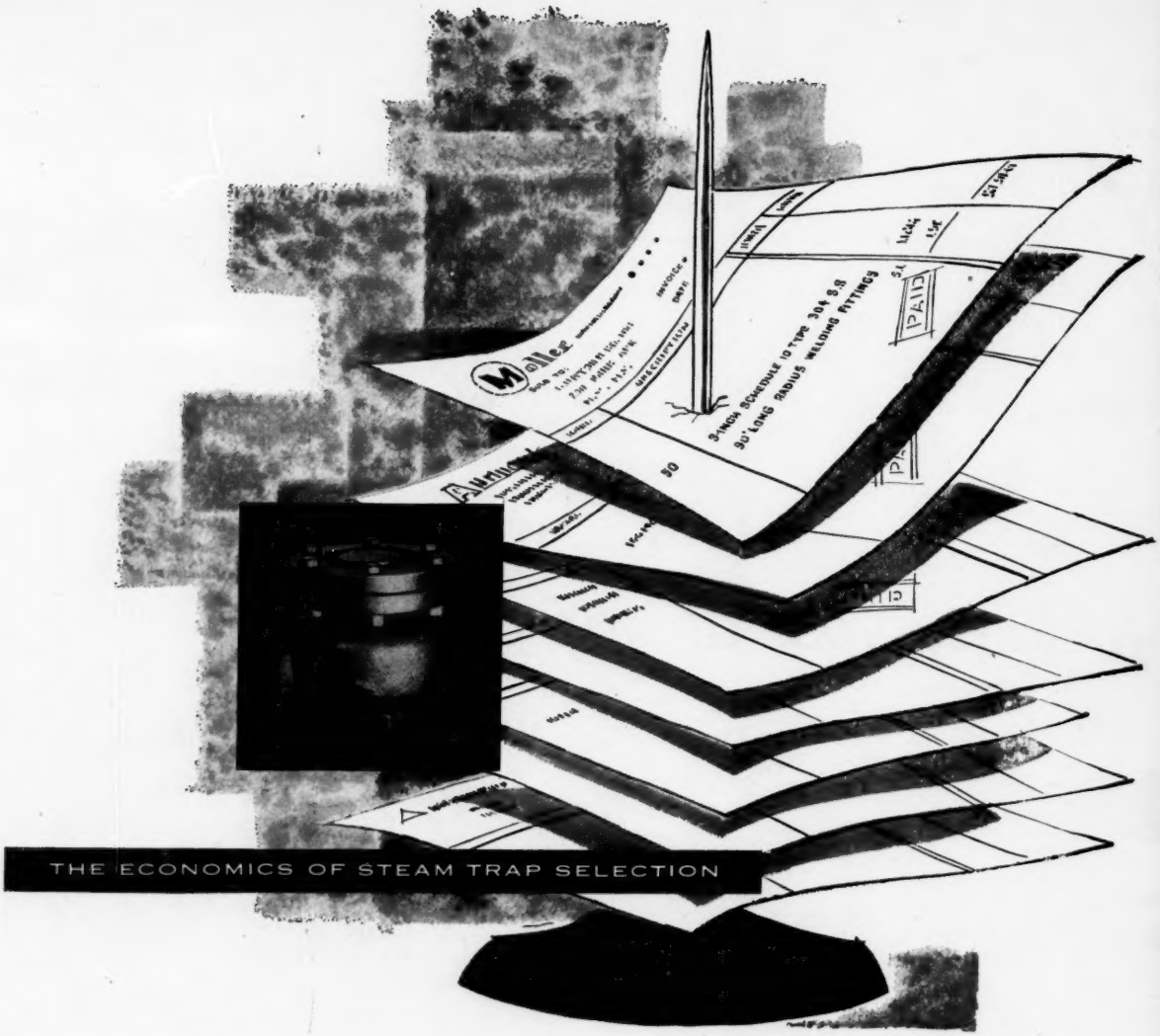

When is the first cost the last cost?

One way to find out is to examine the service records of steam trap installations. Start with a new installation, then learn how long the traps remained in service before they had to be replaced.

At replacement time, was the same brand specified? Or was it found to be inadequate, and a better trap substituted? If substitution was made, why didn't the buyer choose the better brand in the first place?

First cost is last cost only when useful service life, not initial price, is the primary consideration. ST-101

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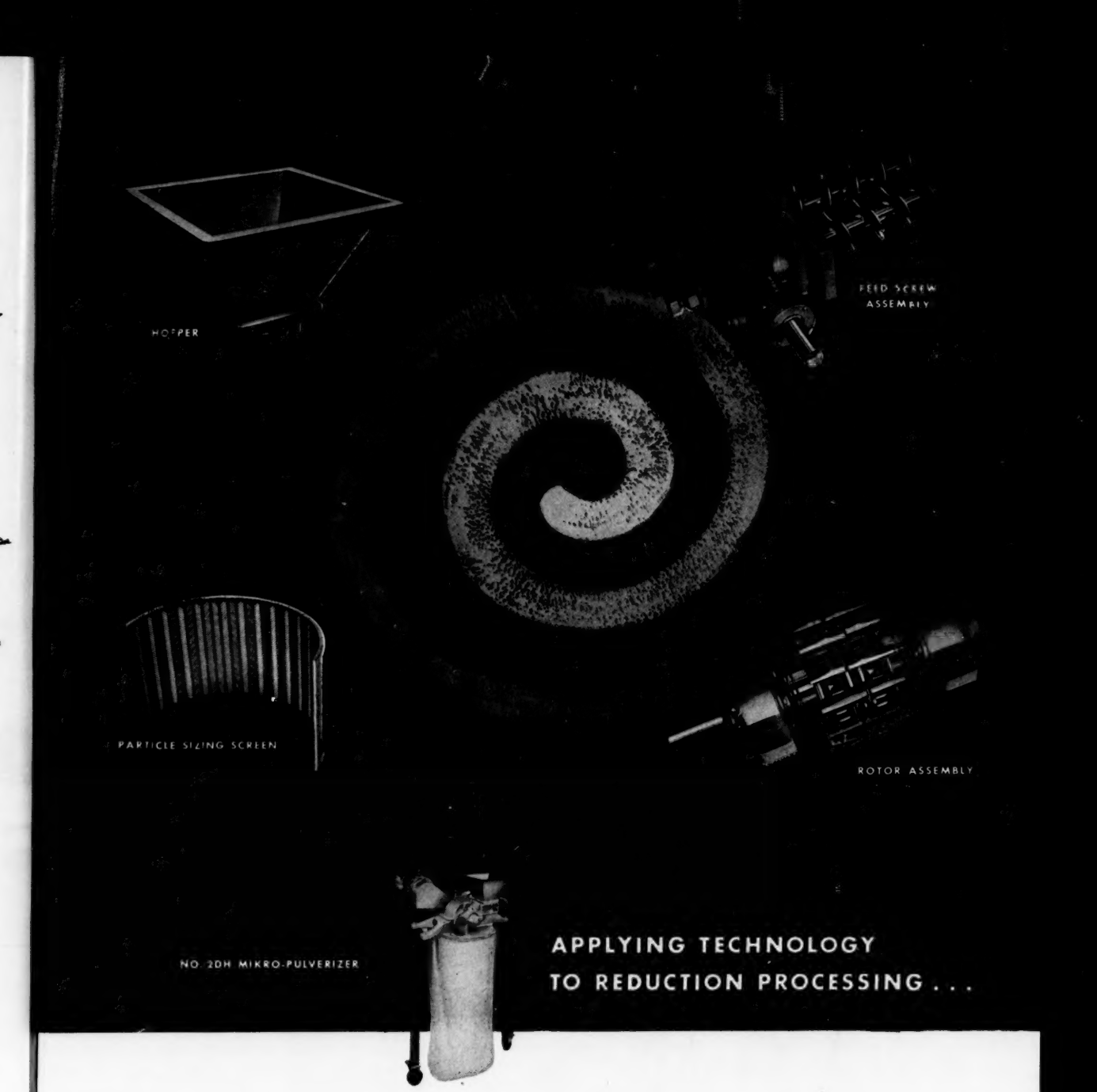

APPLYING TECHNOLOGY TO REDUCTION PROCESSING . . .

Take a look at the "works" of a MIKRO-PULVERIZER, and you'll have a pretty good idea why these units have been receiving the nod of approval from the processing industries for so many years. It's not just a "grinder" . . . but a precision-engineered unit in which each component is carefuly machined and balanced, held to close, uniform tolerances. And this is true of the entire MIKRO-PULVERIZER line, from the smallest pilot plant mill to units producing upwards of ten tons per hour! You'll find the Mikro Laboratories at your disposal, ready to test grind your product and help you select the unit for your particular requirements. As an additional assurance, we're set up to ship genuine Mikro replacement parts to you within 48 hours of order. Bulletin 51A has the full story of models and capacities. It's yours for the asking, with no obligation.

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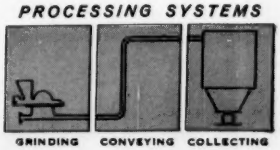

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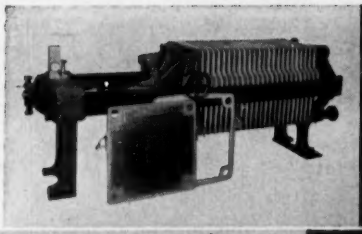
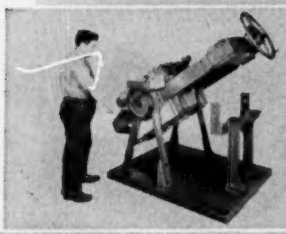
REPRESENTATIVES throughout the United States, Continental Europe, British Isles, Canada, Mexico, Central and South America, West Indies, South Africa, India, Japan, Philippines, Australia and New Zealand.

MANUFACTURING FACILITIES: United States, Canada, Continental Europe, British Isles.



S — FILTER PRESS

Most widely used, most versatile and flexible in application; produces uniform, dense cakes which can be effectively washed or extracted; uses any filter medium or filter aids; handles high viscosity materials at high pressure.

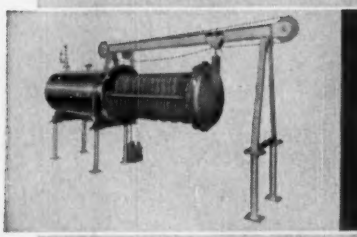


h — "TILTYPE" FILTER PRESS

Uniform cakes lie horizontally while filtering; frames are dumped when in vertical position, allowing easy handling. Filtration can be started and stopped at will.

r — CONTINUOUS THICKENER

For thickening, washing, extracting or leaching at increased rate, independent of settling rate of solids; requires less floor space and head room than settling type thickeners.



i — HORIZONTAL TANK—VERTICAL LEAF FILTER

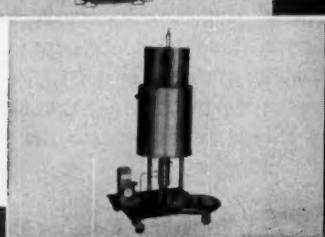
For efficient, large-volume clarification of slurries with maximum of 3 to 6% solids; quick discharge of cake and easy cleaning; no leakage, contamination or loss of liquid.

v — ROTARY LEAF SLUICING FILTER

Has rotating leaves so that spray from sluicing nozzles impinges directly on every square inch of filter area to completely remove cake as a slurry through screw conveyor, without opening filter.

e — VERTICAL TANK—VERTICAL LEAF FILTER

For clarifying slurries containing low percentage of compressible solids of no value; uniform, high filtration rate; used with precoats; solids quickly cleaned or sluiced out.



r — ENCLOSED TANK HORIZONTAL PLATE FILTER

Forms cakes of uniform density and of desired thickness; no unfiltered material and no pressure in tank; fast flow rate; uses any filter medium; also can wash, extract and dry cake.

We Sell FILTRATION *not* the Filter

The Shriver pressure filters you see here are representative of many types we design and produce. Nevertheless, the filter we may suggest for your needs —after careful tests and study— may not necessarily be in the Shriver line. As a matter of fact, manufacturers of other types of filters are often beneficiaries of our analyses. For ours is a scientific, practical approach to your filtration problem, based on a wealth of ideas, talent and experience. Recommendations are always made in your best interest. That is why at Shriver's "We sell filtration" and the filter the process calls for then sells itself. May we be of assistance?

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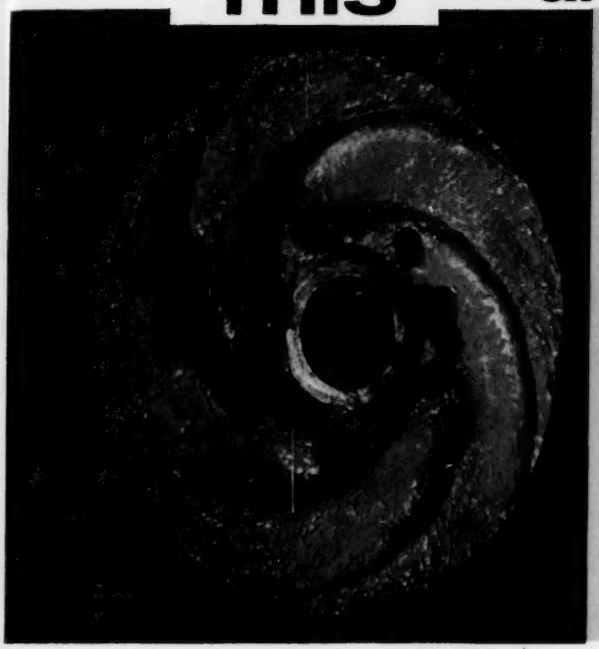
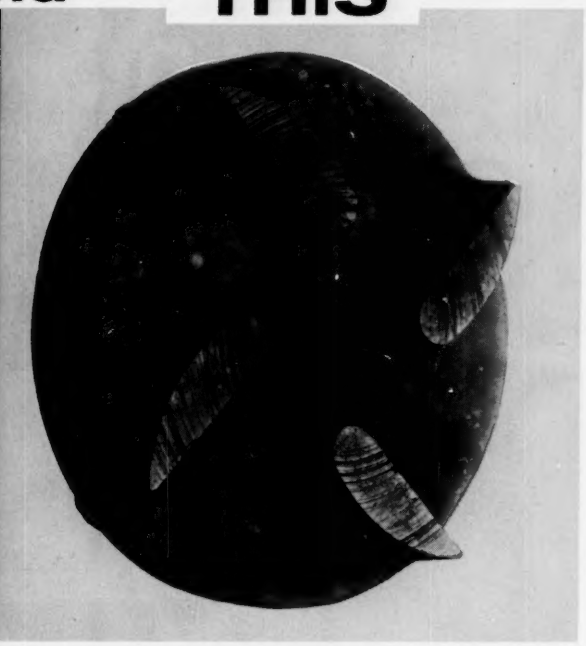
THE DIFFERENCE BETWEEN THIS and THIS





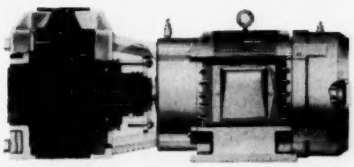
is a corrosion-resistant
"KARBATE" IMPERVIOUS GRAPHITE PUMP!

Why? Because "Karbate" impervious graphite offers total corrosion resistance. It does not rely on a coating or an easily abraded passive or protective film. This absence of corrosion wear in "Karbate" impervious graphite pumps provides continuous, maximum operating efficiency in all recommended applications.

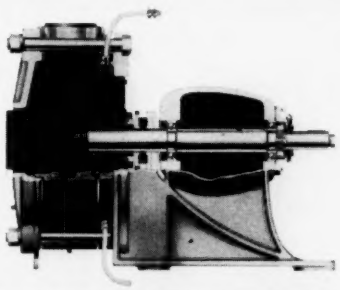
As these facts show, few other pumps — regardless of price — can handle as wide a variety of corrosives as "Karbate" impervious graphite pumps. They are resistant to: *mineral acids* such as *hydrochloric, sulfuric, phosphoric; acid combinations* such as *nitric-hydrofluoric, phosphoric-sulfuric; chlorinated hydrocarbons; alkalies; and organic* and *inorganic compounds of all types.* In practically all of these corrosives, changes in temperature and concentration will not affect the corrosion resistance of "Karbate" impervious graphite.

A "Karbate" pump user comments, "We installed these pumps because they could handle our present variety of solutions and would resist any additional corrosive effects of future changes in these solutions".

In addition to excellent corrosion resistance, these pumps are rugged in construction . . . low in cost . . . and are readily available from stock in a wide variety of models and sizes. **You can pay more but you can't buy a better corrosion resistant pump.** Write for pump literature today!



TYPE F MOTOR-MOUNTED "KARBATE" CENTRIFUGAL PUMP
Cross-section illustrates typical "Karbate" motor-mounted pump recommended for heads to 70 feet — capacities to 140 gpm.



TYPE C FRAME-MOUNTED "KARBATE" CENTRIFUGAL PUMP
Cross-section shows typical "Karbate" frame-mounted pump recommended for heads to 120 feet — capacities to 1500 gpm.

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For the Automotive Industry
Variators give accurate control of assembly line speeds to control conveyor output rates.

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Variators provide remote control speed change on processing line conveyor.

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Variators permit fast, accurate adjustment of machining speeds for metals, from magnesium to 38 Rc steel.

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Variators control four reels simultaneously — and without slippage.

In Ore Processing
Variators easily adjust rate of material feed to hammermill.

In Material Handling
Variators control movement of steel tubes through 176-roll annealing furnace.

HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, right).

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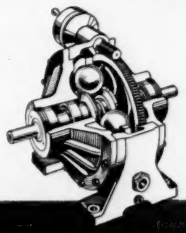

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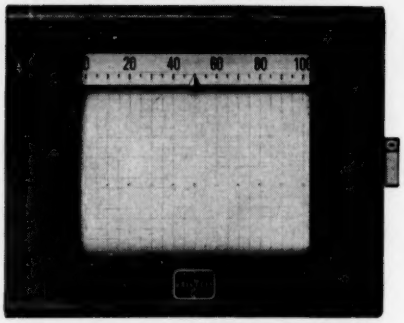
World's first mobile, self-contained nuclear power plant and first U. S. gas-cooled reactor for generating power—these are the dual aims of the Gas-Cooled Reactor Experiment Program (GCRE-I), being carried out at the National Reactor Testing Station, Idaho, for the U. S. Army and U. S. Atomic Energy Commission by Aerojet-General Nucleonics.

We're proud that Aerojet-General, prime contractors for the Army Gas-Cooled Reactor Systems Program and builders of both the reactor and its control system, selected Bristol Dynamaster* potentiometer and bridge instruments to record vital reactor data.

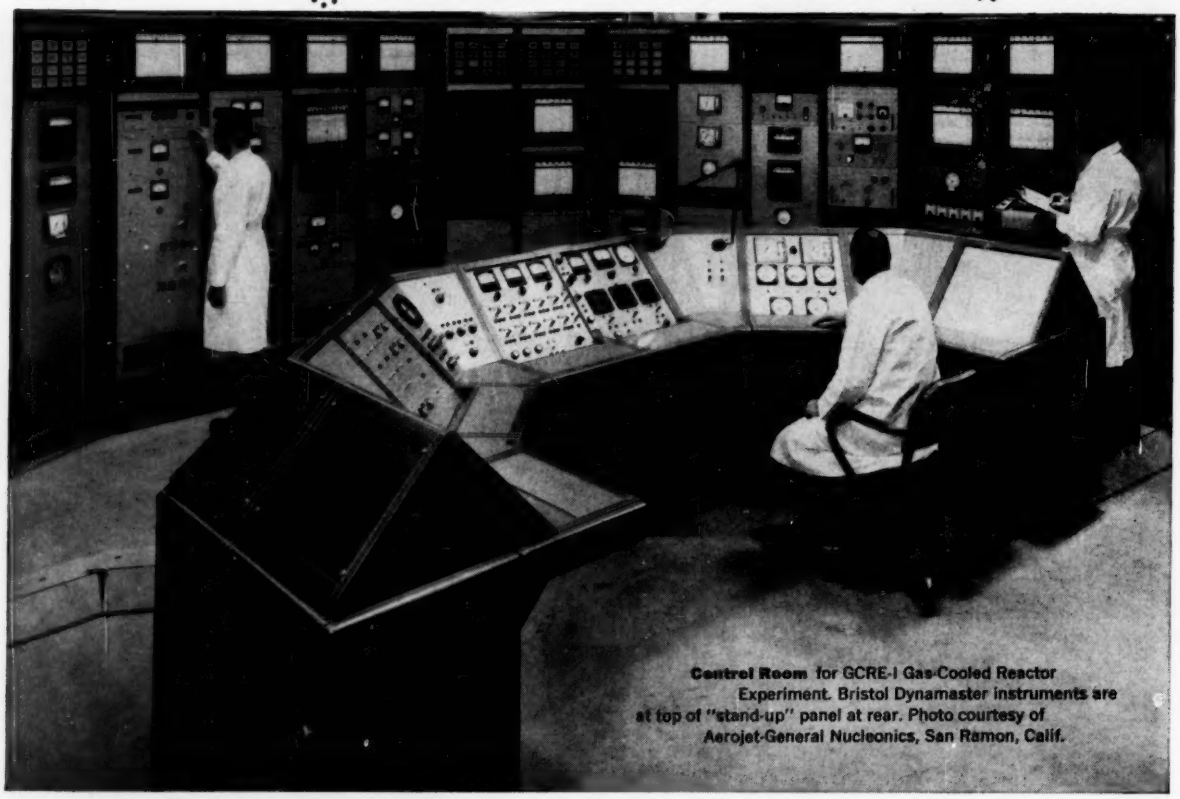
Bristol offers control-systems builders—whether for the nuclear or any other industry—the widest instrument choice on the market for measurement, recording, automatic control, and telemetering. Electronic and pneumatic types. Full-size and miniature (3" strip chart) types. For complete data, write: The Bristol Company, 109 Bristol Road, Waterbury 20, Conn. 9.25

Bristol Dynamaster* Electronic Potentiometer or Bridge Instrument, strip-chart model.



**T. M. Reg. U.S. Pat. Off.*

BRISTOL INSTRUMENTS *record Army reactor's progress*



Control Room for GCRE-I Gas-Cooled Reactor Experiment. Bristol Dynamaster instruments are at top of "stand-up" panel at rear. Photo courtesy of Aerojet-General Nucleonics, San Ramon, Calif.

BRISTOL... for improved production through measurement and control

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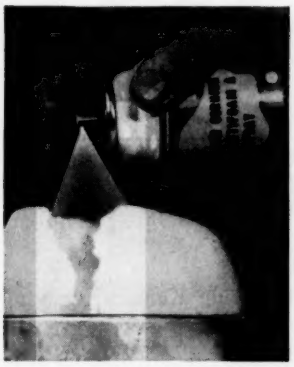
Control Foam in Any Type of System with Low Cost Silicone Defoamers

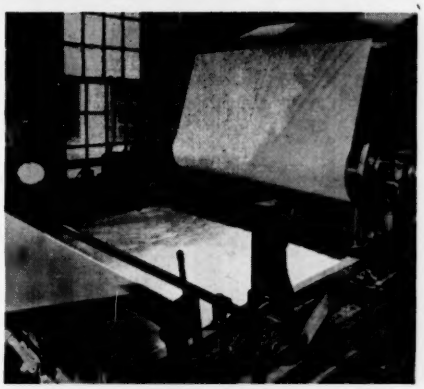
Does foam occur in your process operations? Chances are you can keep it under control at all times with a Dow Corning silicone defoamer. Job-proved in virtually every industry . . . petrochemical, textile, paper, paint, food and many others . . . Dow Corning silicone defoamers knock down the most violent and persistent foam. Eliminate processing slow-downs and boil-overs. Reduce fire hazards. Cut waste and clean-up costs.



AVAILABLE IN HANDY SPRAY CAN

And Dow Corning silicone defoamers are amazingly effective in minute quantities. For example, just 1 ounce of a Dow Corning silicone defoamer prevents foam in 31,250 pounds of dog shampoo, in 59,110 pounds of wire drawing solution, and in 62,500 pounds of paper coating solution . . . are similarly effective in defoaming adhesives, latices, caustic liquor, soap, varnish, emulsion paints and coatings, cutting oils, petrochemicals, food products . . . many, many others.

Dow Corning's continuing research study of foam and its control has brought about the availability of silicone defoamers as compounds and emulsions for different types of production systems — and in handy spray cans for split-second defoaming of smaller batch processes. Settle your foam problems once and for all time with a Dow Corning silicone defoamer. A generous trial sample is yours for the asking. Indicate your problem and system — oil, aqueous, nonaqueous, food product, or any other. Write Dept. 2603 for a rapid reply.



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a Reminder

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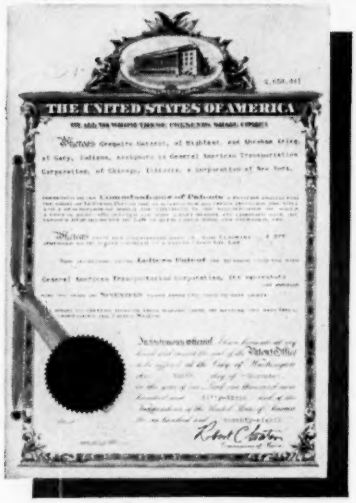

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and 29 patents prove it

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Why a Steam Trap Has to Handle "Air"

Low temperatures and corrosion of equipment are often evidence of inadequate trap air venting capacity

Air, with its load of oxygen and carbon dioxide, has an unwholesome habit of interfering with the efficiency of steam heated units. If steam were always free of these undesirable companions, things would be a lot simpler for men-who-operate-plants. Because it isn't, three unhappy situations frequently occur:

1. ***Operating temperatures are subnormal.*** This is a two-part problem. First, an air-steam mixture has a lower temperature than pure steam at the same pressure—see Table A. Secondly, air can "plate out" on heat transfer surfaces as shown in Figure 1. Under some conditions, such an air film will knock down heat transfer efficiency by as much as 50%.

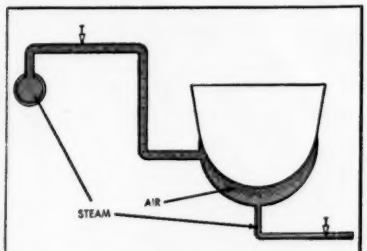


Fig. 1. *How air can "plate out" on heat transfer surfaces. This "insulation" drastically reduces heat transfer efficiency. Armstrong trap operation creates turbulence in the equipment that prevents this.*

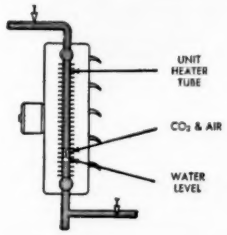


Fig. 2. *Corrosion occurs when units are not kept continuously free of both condensate and air. Armstrong traps discharge both,* at steam temperature, *as fast as they accumulate.*

2. ***Corrosion rears its ugly head.*** Oxygen and carbon dioxide are real trouble-makers. CO_2 gas goes into solution in condensate, forms carbonic acid and chews away at vulnerable metal sections. O_2 aggravates the situation. See Figure 2.

TABLE A—How air reduces steam temperature.

Gauge Pressure	Temp. of Steam with No Air Present	Temp. of Steam Mixed With Various Amounts of Air (% Air by Volume)	
		10%	30%
10.3	240.1	234.3	220.9
25.3	267.3	261.0	246.4
50.3	298.0	291.0	275.1
75.3	320.3	312.9	295.9
100.3	338.1	330.3	312.4

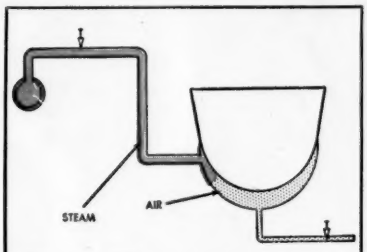


Fig. 3. *When steam is turned on, it takes a trap with extra air venting capacity to provide fast heat-up.*

3. ***Heat-up is slow as a snail.*** Air has a picnic in units that are shut off periodically. Figure 3 pictures the problem. Lines and equipment literally fill up with air. When the steam is turned on it can get in only as fast as the air gets out.

Enter Steam Traps

Curing these steam system ailments involves an operation sometimes called a "trap transplant." It consists of removing traps that don't get the air out and replacing them with traps that do.

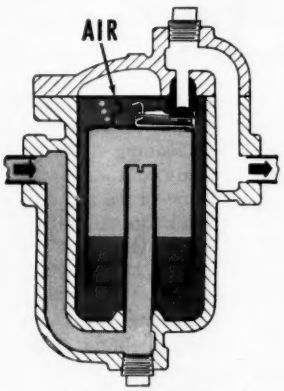
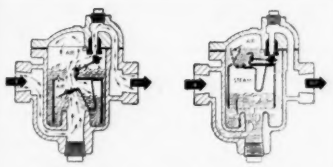


Fig. 4. *Air entering an Armstrong trap passes through the bucket vent and accumulates in the top of trap. When trap opens, air is discharged along with condensate.*

Figure 4 shows how an Armstrong inverted bucket trap continuously vents air. What the picture doesn't show is a built-in plus-value of this trap's design. An Armstrong trap opens suddenly, creating a momentary pressure drop and turbulence in the unit being drained. This breaks up air films and "pumps" air down to the trap so it can be vented.

The vents in standard Armstrong trap buckets will pass all the air normally encountered. In special cases, such as paper machine dryers, the vents are correctly sized larger at the factory to meet the requirement.



Thermostatic vent open. *Thermostatic vent closed.*

Fig. 5. *Open float with thermostatic vent for off-and-on units. When trap is cold, vent is open, permitting air to blow through when steam is turned on. When steam reaches trap, heat closes thermostatic vent. Then, regular bucket vent handles all air coming in with steam.*

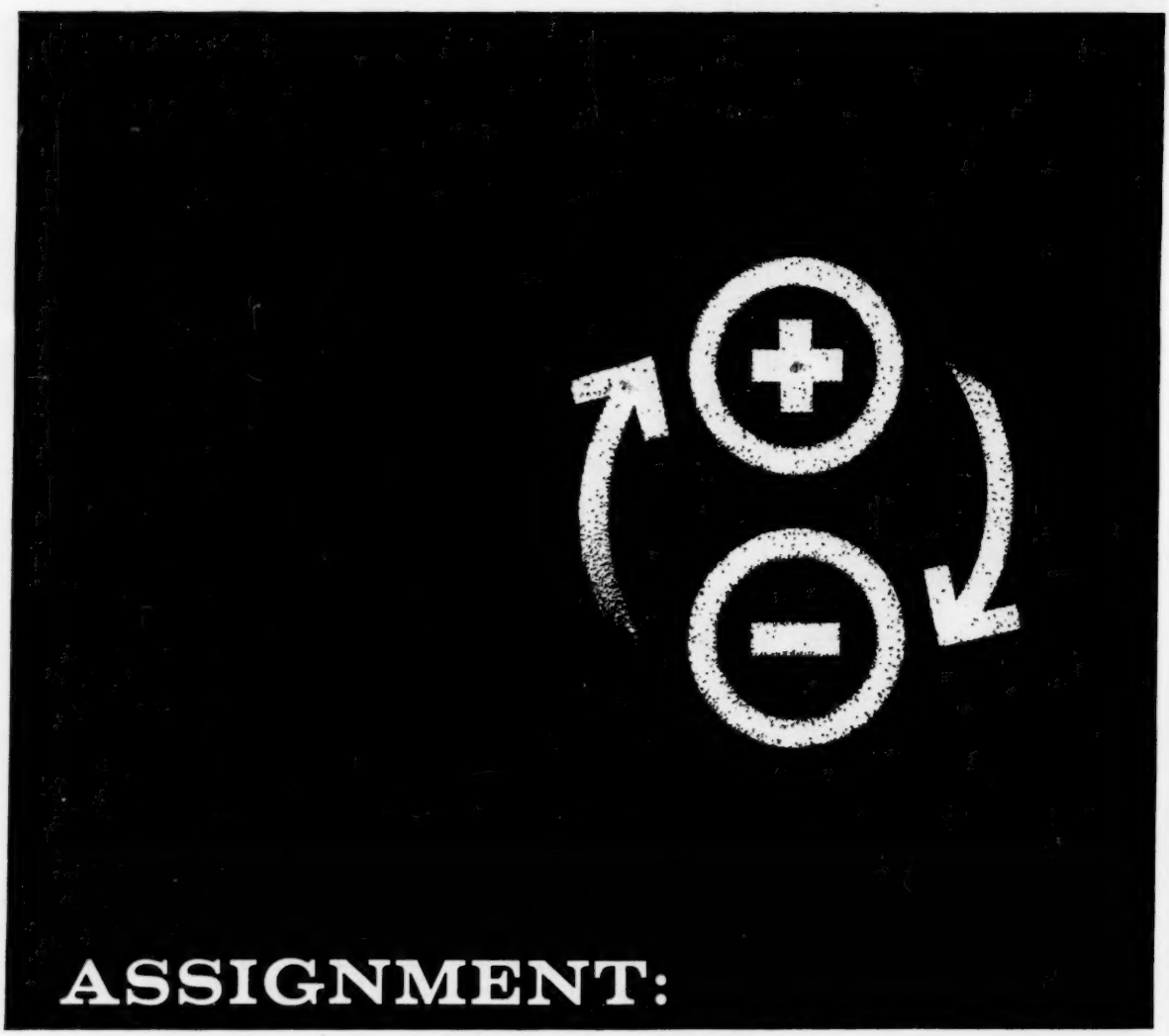
Open Float with Thermostatic Vent

Super air-venting capacity is a must for fast heat-up of low pressure unit heaters, heating coils, steam headers and other units that are on-and-off. Figure 5 shows how the Armstrong open-float-with-thermostatic-vent trap takes care of this.

* * *

The 44-page Armstrong steam trap book covers other features of the Armstrong trap as well as its excellent air handling characteristics. This catalog also discusses trap selection, installation and maintenance. Your local Armstrong Representative or Distributor will be glad to give you a copy. Call him, or write Armstrong Machine Works, 8587 Maple Street, Three Rivers, Michigan.

ARMSTRONG STEAM TRAPS



ASSIGNMENT: CORROSION

How Lukens *Application Research* can help you find the right steel plate for the job

Migrating ions—superimposed on a photomicrograph of corroded steel plate—symbolize one of metallurgy's oldest assignments: the battle against corrosion. Developing new tactics in this constant campaign is the job of our Application Engineering staff.

For example, called on early in the planning stages, Lukens engineers recently attacked almost identical problems for two large processing companies—and came up with two completely different solutions.

The first involved a sugar refiner's vacuum pans. Frequent and costly cleaning was required to head off corrosion and product contamination. Our staff's prior research and experience in the food equipment field led it to suggest *nickel*-clad steel for the pans. (13% and 8% nickel-clad on A-285 backing steel.)

Cleaning and maintenance were equally costly to a leading chemical and dye company—in the protection of its nitrogen solution barge tanks. Here, our engineers found *stainless*-clad steel the most desirable answer. (12% 304L on A-212 backing steel.)

Armed with practical as well as technical knowledge of Lukens' wide range of special-duty steels, our Application Engineers have helped conquer corrosion on many fronts. That's why we say . . . *if your assignment is corrosion, let it be our assignment, too.* Contact Manager, Application Engineering, H-30 **Services Building, Lukens Steel** Company, Coatesville, Pa.

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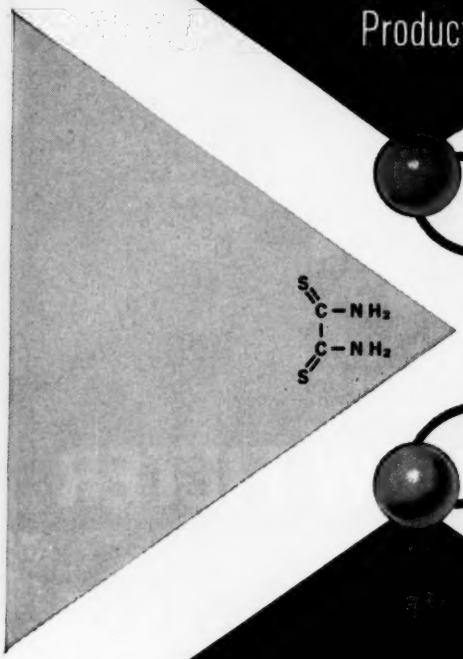

DITHIOOXAMIDE

Mallinckrodt Chemical Works, St. Louis, Missouri, recently announced this new building block...a chemical that can go in many directions to create new and better products. For example, the manufacturer suggests applications for dithiooxamide and its derivatives in the fields of metal sequestrants, pigments, organic intermediates and plant growth regulators.

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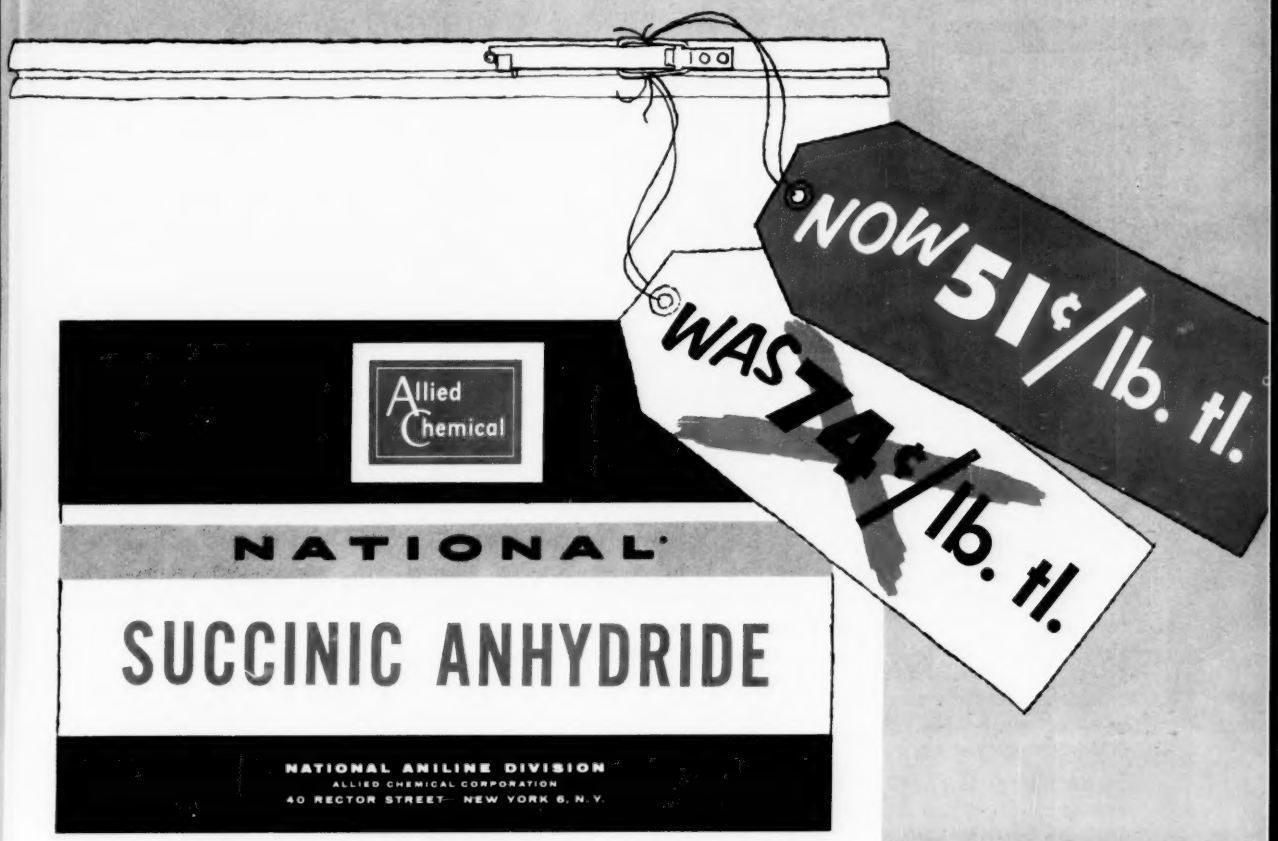
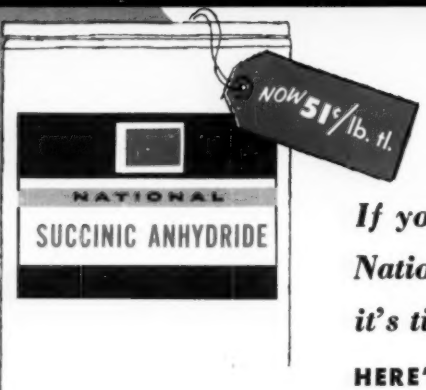


New low "incentive price" offered to stimulate volume use in coatings, resins, plasticizers, elastomers, adhesives, etc.

Future substantial price reductions probable if consumption grows as contemplated.

READ FULL DETAILS OF HOW YOU CAN BENEFIT



If you have considered National SUCCINIC ANHYDRIDE too costly for your use, it's time now to take another look!

HERE'S WHY...

We are so sure that National SUCCINIC ANHYDRIDE should and can be a major intermediate that we are underwriting future volume with a very attractive "incentive price" *now*.

Even more important, your volume use can help bring additional price reductions that will make the ultimate cost of using this reactive organic comparable to that of other widely used resin chemicals.

So you have every reason to re-examine National SUCCINIC ANHYDRIDE *now*. We'll make it easy for you to do so!

WHY NATIONAL SUCCINIC ANHYDRIDE?

National SUCCINIC ANHYDRIDE has an unusually interesting molecular structure — what researchers colloquially call a "small molecule" — that imparts many desired properties to coatings, resins and plasticizers. At our new low "incentive price" (and with anticipated future reductions based on substantial increased consumption), it can be the basis for many improved end-products.

And, at its new low price, National SUCCINIC ANHYDRIDE should now find increasingly important use in pigments, pharmaceutical intermediates, cosmetic ingredients, perfume bases, corrosion preventives, photographic chemicals, lube oil additives, insect repellents and the like.

Its reactions commend re-study by those who work with esters, acyl compounds, lactones, pyrroles as well as intermediates leading to five-membered cyclic structures.

WHAT IS NATIONAL'S POSITION?

National is America's only producer of SUCCINIC ANHYDRIDE for sale. We have long experience, integrated production and efficient manufacturing processes.

For new users, we can promptly supply laboratory and pilot-plant quantities from our present production. Additional capacity should be on stream in the near future.

We are prepared to install ever-increasing capacity with cumulatively decreasing costs to make National SUCCINIC ANHYDRIDE a major resin chemical as well as an important economic organic intermediate.

WHAT YOU SHOULD DO NOW

Be sure your Research, Product Development and Marketing people see this announcement. Discuss it with them.

Find out what National SUCCINIC ANHYDRIDE at 51¢/lb. can do to increase your sales and open new product opportunities.

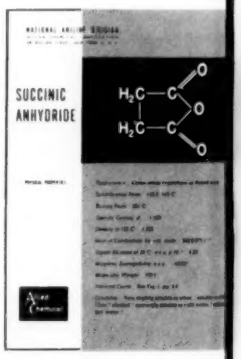
Check what possible future substantial price reductions (based on increased consumption) can do to further increase your sales and profits.

Then — let us know your anticipated needs so we can work with you.

Research & Product Development Men:

HERE'S THE TECHNICAL DATA YOU NEED

Our 40-page Technical Bulletin I-11 SUCCINIC ANHYDRIDE contains complete physical properties, all important reactions, infrared absorption spectrogram, suggested uses and a bibliography of 302 references – all the fundamental data needed for your investigations. Ample working samples will be sent without charge. Use the convenient coupon below for prompt action.



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Four-Wheel Brakes: Powerful hydraulic type, and sealed to keep out dust and dirt.

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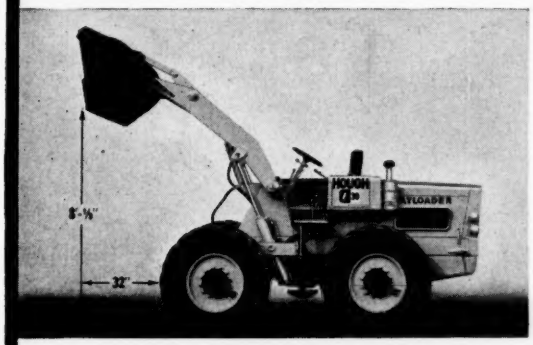

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®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

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Low maintenance cost.

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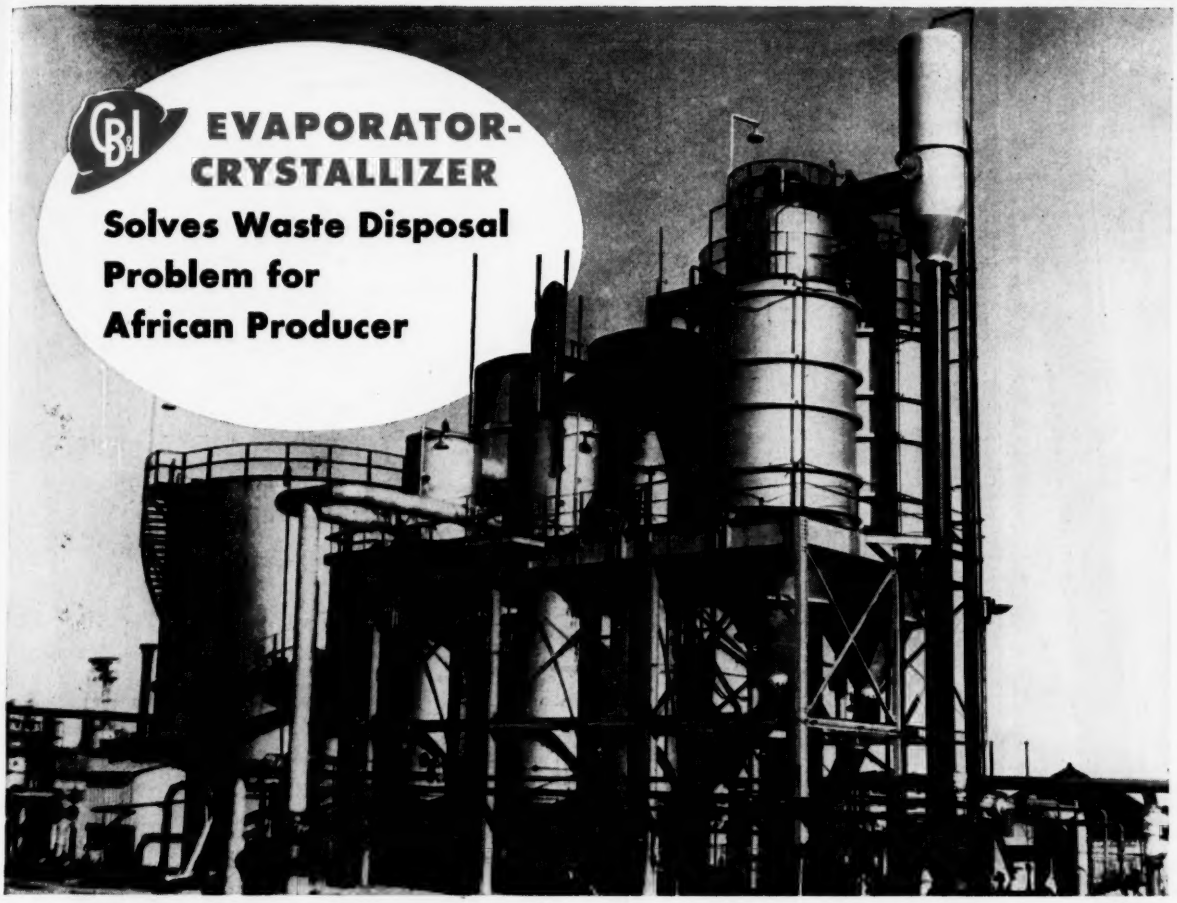

Continuous operation reported where tough scale problem was anticipated

This four-body, triple effect CB&I Evaporator-Crystallizer was put to work by the South African Coal, Oil & Gas Corporation to process an effluent waste plant liquor—and to produce crystallized acetate compounds from it.

In designing the unit, CB&I engineers were careful to provide for ease and expediency of cleaning and service . . . because of the high scaling tendency of the material. In addition, the unit was built to operate under a special large volume recirculation technique designed to inhibit scale formation. After many months of operation, the plant reports that loss in production time for cleaning amounts to only 3%. Due to the serious plant operating problem that exists when the evaporator-crystallizer is down the unit runs continuously, even during cleaning.

This report shows why so many CB&I customers are *repeat* customers. CB&I equipment is engineered and adaptable to the most exacting operating requirements. As a result, CB&I customers are accustomed to turning a *profit* from high, uniform crystal production—at low operating cost. Write our nearest office for further details on CB&I-built evaporators, crystallizers and filters.

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CB&I triple effect evaporator-crystallizer at Coalbrook, South Africa has helped South African Coal, Oil & Gas Corporation to solve a difficult waste disposal problem and to recover crystalline materials which may eventually prove to be a new, marketable product.

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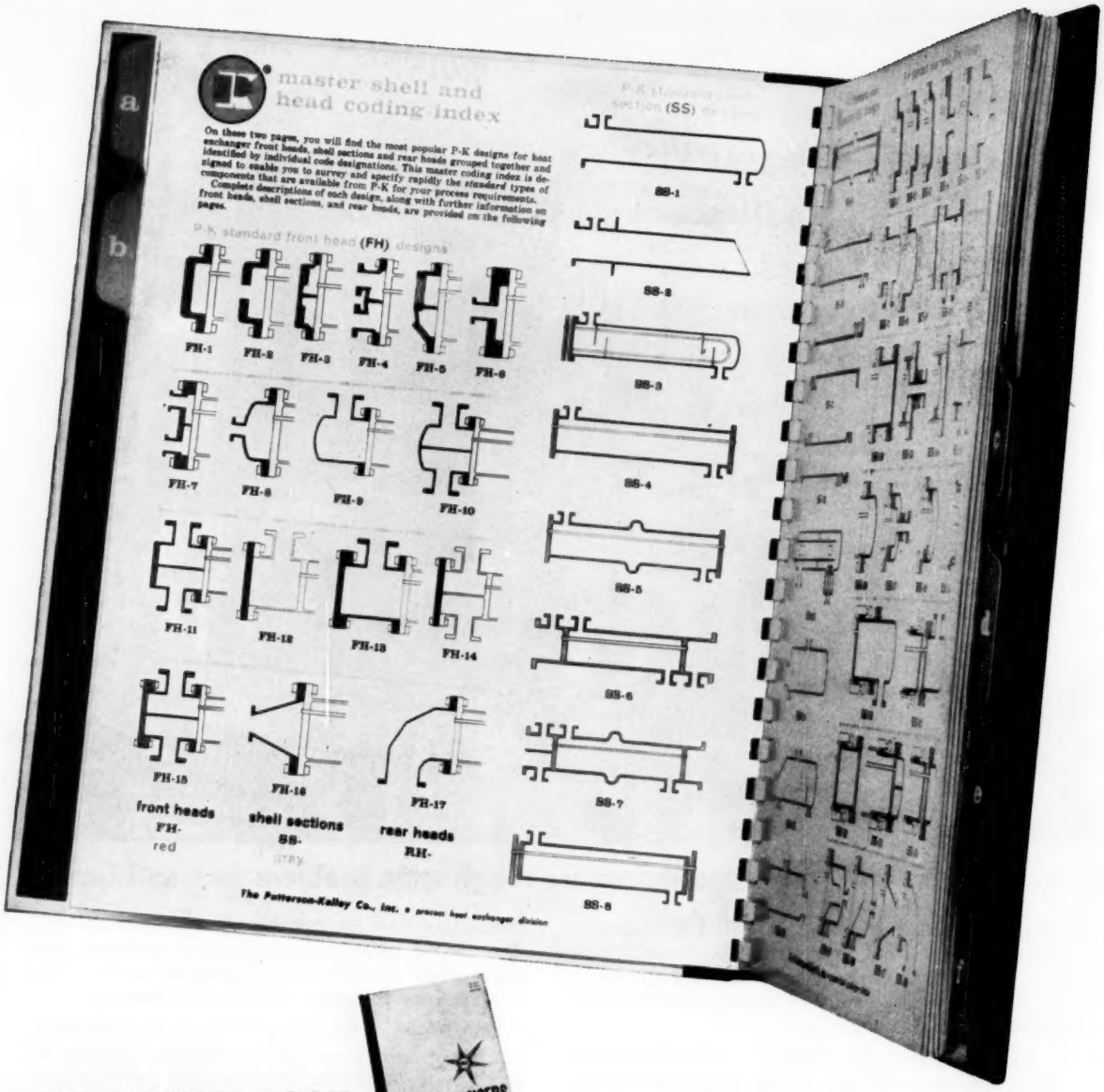

NEW WORK BOOK SIMPLIFIES HEAT EXCHANGER SELECTION

The need for a standard terminology to simplify communications between P-K and engineers in the chemical processing industry has been met in P-K's new Heat Exchanger Manual.

This unique communications tool illustrates and describes components of shell and tube heat exchangers commonly used in processing. A complete system of interchangeable front heads, shells and rear heads is established. Fundamentals of heat transfer and design are reviewed. Even economic considerations are discussed. The simple, certain nomenclature saves time, effort and duplication of engineering work.

This 120-page manual, indexed and bound in hard covers, will be supplemented from time to time with new technical material. Names of holders will be registered to receive such material as it appears.

Only a limited number of copies is available and, naturally, these should go to those in the process industries who will benefit most from the information we have compiled. If you design or specify heat exchangers, write us on your company letterhead, outlining briefly areas of your interest. A few copies are available to students and non-technical personnel at a nominal charge. Patterson-Kelley Co. Inc., E. Stroudsburg, Pa.

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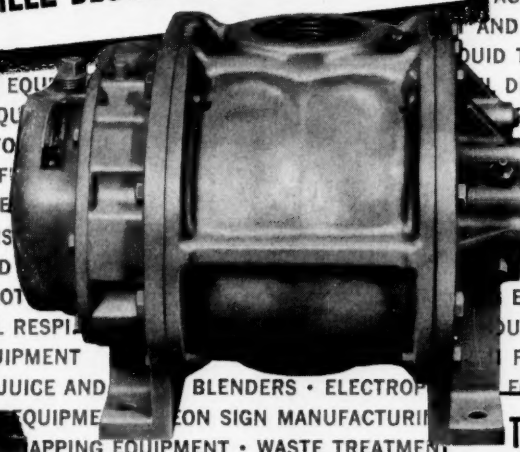
ROOTS-CONNERSVILLE BLOWERS & GAS PUMPS



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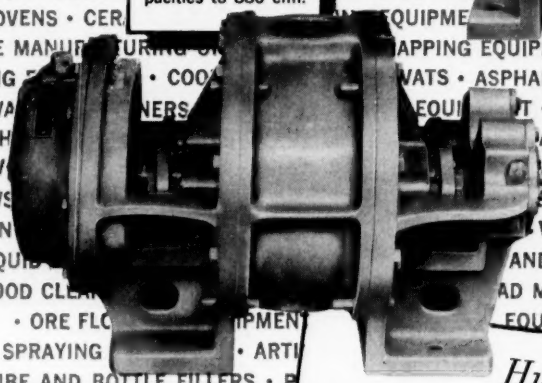
18 sizes for pressures to 6 psig; capacities to 880 cfm.



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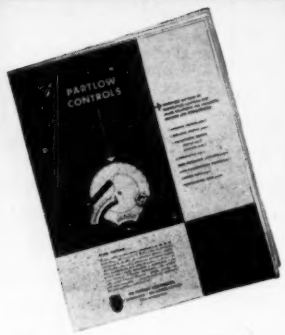


Send for free brochure, PARTLOW CONTROLS... A handy, condensed catalog of the complete line of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

FAST, ON-TARGET DELIVERIES . . .

Another reason why more firms than ever are using Partlow Temperature Controls

Much of Partlow's business involves special controls to solve special application problems.

No matter how off-standard the control, however, the odds are better than 99-to-1 that the Partlow you order will be delivered well within our regular 3-to-4 week schedule. During the past 12 months — the busiest in our 40-year history — 99% of all the controls we produced went out *on time*, or ahead of it!

Of course, prompt, dependable delivery is only one reason for the mushrooming demand for Partlow products. Here are a few others:

Mercury Actuation, which lets the Partlow function without an outside power source or temperamental electronic amplification . . .

Unmatched Design Simplicity, which enables the Partlow to withstand even extreme conditions of shock, vibration, corrosion, dust and moisture, without loss of accuracy or sensitivity . . .

Interchangeability of Elements, which makes it possible for any Partlow to be serviced at the job site, virtually eliminating "down time."

Partlow makes a complete line of electric, mechanical and pneumatic controls (recording, indicating and non-indicating) for temperatures up to 1100°F. Whatever your application problem, Partlow makes an instrument to handle it efficiently, economically, *precisely*. Write for details: The Partlow Corp., New Hartford, N. Y., Dept. E-310.

PARTLOW
TEMPERATURE CONTROLS

World Export:
Ad. Auriema, Inc., 85 Broad Street, New York 4, N. Y.

Dateline: Formosa

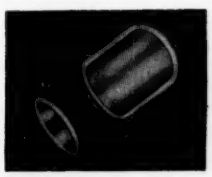
Bridgeport Duplex Tubes Solve a Chinese Corrosion Puzzle

The recently completed urea plant for Taiwan Fertilizer Company, Ltd., on Formosa, will increase fertilizer production so necessary to the Chinese Nationalist agricultural economy. Designed according to the Inventa-Vulcan process, the urea synthesis section of the huge installation utilizes a number of specially designed heat exchangers in various processing steps.

One of the many problems that had to be faced was to find a heat exchanger tube capable of meeting the combined corrosive attack of both the cooling water and the process stream. The natural corrosive qualities of water in the raw state were heightened by the periodic injection of chlorine to kill living organisms. The process fluid, on the other hand, presented an entirely different set of problems. No single alloy could cope with both corrosive media. As is often the case in such circumstances, the solution was found in Bridgeport Duplex Tubes made by drawing two different alloy tubes to form one mechanically bonded bimetal tube.

The effectiveness of Bridgeport Duplex Tubes in such applications as chemical processing, refineries and food processing, is as widespread as their use. They are available in a wide variety of alloy combinations to meet virtually any corrosive problem.

For full details, call your nearest Bridgeport Sales Office or write direct for the new BRIDGEPORT DUPLEX TUBE MANUAL. Dept. 5003



Bridgeport Duplex Tubes are bimetal tubes—two tubes combined into one. With them, you can select the metal alloy surface best suited to meet the corrosive attack to which it is exposed.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

Will success spoil the 53P controller?

Success due to luck may spoil . . . but the 53P has *earned* its recognition over the years with a combination of advantages offered by no other pneumatic controller. Standardized design for top level performance has won the 53P an honored place in the process loop . . . behind the panels, in the instruments, and along the catwalks of the country's most progressive plants.

The only standardized controller

One basic 53P accepts pneumatic or mechanical inputs. You get the same performance whether you mount it in a large case instrument, plug it onto a miniature recorder, or field mount it. The same controller permits everything from proportional to three-mode control . . . and the new "universal" offers 2 to 50% proportional and 2 to 100% differential gap action in the same units!

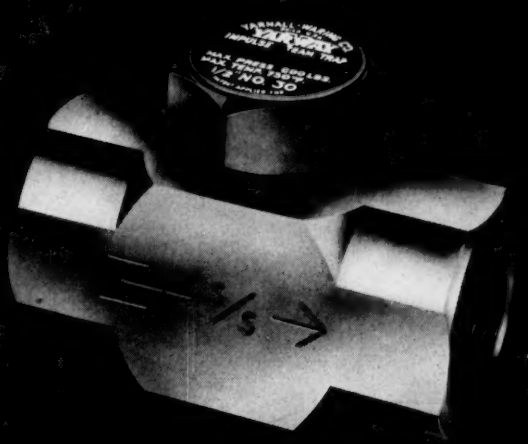
The only regenerative feedback controller

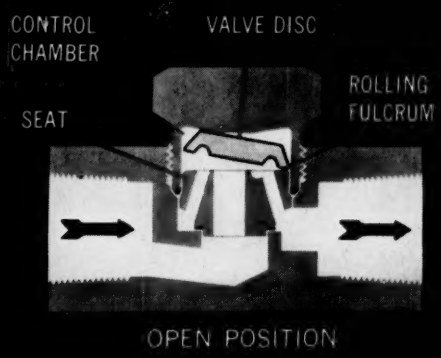
Only the 53P incorporates the F&P principle of regenerative feedback to give you improved linearity and increased gain. A non-bleed type amplifying relay assures low air consumption (.08 scfm, steady state). No other controller offers all these features or equals the static and dynamic performance characteristics built into the 53P. You'll find any number of reasons for the success of the 53P controller in Catalog 53P-4000. Write for your copy, or call the F&P field engineer nearest you. Fischer & Porter Company, 130 County Line Road, Warminster, Pa. In Canada, Fischer & Porter (Canada) Ltd., 2700 Jane St., Downsview, Ont.

FP FISCHER & PORTER COMPANY *COMPLETE PROCESS INSTRUMENTATION*

These MANUFACTURING AFFILIATES carry Fischer & Porter engineering designs to the far corners of the earth: FISCHER & PORTER (CANADA) LTD., DOWNSVIEW, ONTARIO. • FISCHER & PORTER LTD., WORKINGTON, CUMBERLAND, ENGLAND • FISCHER & PORTER G.m.b.H., GROSSELLERSHAUSEN, BEI GOTTINGEN, GERMANY • FISCHER & PORTER N.V., KOMEETWEG 11, THE HAGUE, NETHERLANDS • FISCHER & PORTER Pty. LTD., 184 HANNA ST., SOUTH MELBOURNE, VICTORIA, AUSTRALIA.

Do your steam traps give you these 3 advantages?





1. Economy of operation on light loads?

The Yarway No. 30 gives you closer control—discharges condensate at full capacity, closes immediately on steam.

2. Longer service life?

Yarway's lever action reduces impact on valve seat—lessens wear, gives longer operating life. Quieter operation, too!

3. Lower maintenance?

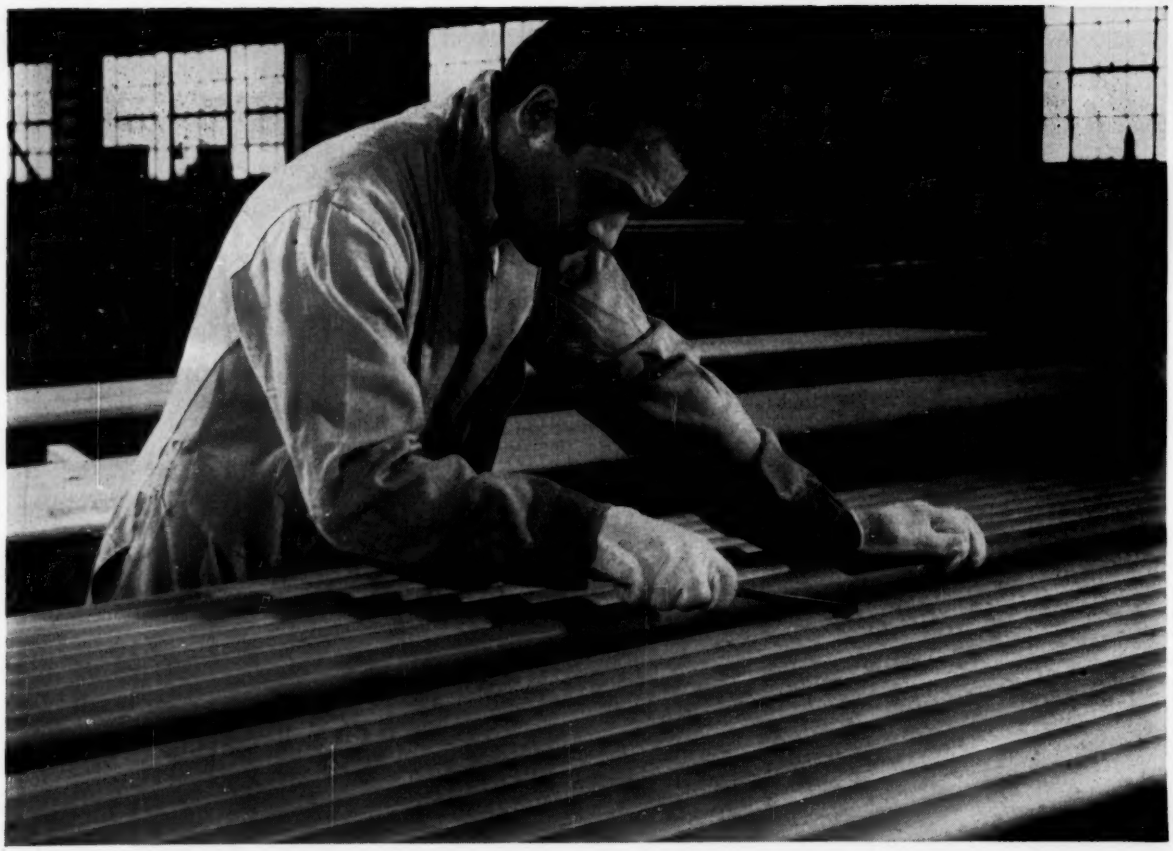
Only Yarway offers an Impulse trap with renewable seat and disc that *can be replaced without removing the trap from the line.*

Why settle for less? Get all three money-saving advantages with Yarway No. 30—plus these time-proven advantages of all Yarway Impulse traps: quick heat-up, even temperatures, small size, stainless steel construction, non-freezing.

Nearly 1,300,000 Yarway Impulse traps already installed. Stocked and sold by 270 Industrial Distributors. Ask *your* distributor to arrange a free 90-day trial in your plant. Or write us.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.

YARWAY
A MARK OF QUALITY IN STEAM ENGINEERING



Stainless pressure tubing that gets white glove treatment

IF you're thinking of using stainless steel pressure tubing to solve a problem, make sure you get your money's worth. Timken® stainless steel pressure tubing is so carefully made it's literally handled with white gloves. That's typical of the quality that's built-in every step of the way. And you get this high internal quality and excellent surface finish, because:

1. **THE TIMKEN COMPANY** has one of the most modern, best-equipped seamless tube mills in the country.
2. **WE PIONEERED** in producing stainless steel tubing for pressure tube applications.
3. **MANY TECHNIQUES** we use are virtually unique in the steel industry.

Experts handle every production step—melting, piercing, finishing, testing, final inspection. The result is, you get the finest stainless pressure tubing you can buy. Tubing proved by performance in hundreds of applications.

Let Timken Company metallurgical experts help solve your stainless pressure tubing problems. You can get Timken stainless steel pressure tubing in a wide variety of sizes and grades—some not available anywhere else. Get the most for your money. Specify Timken stainless pressure tubing. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

WHEN YOU BUY TIMKEN STEEL YOU GET . . .

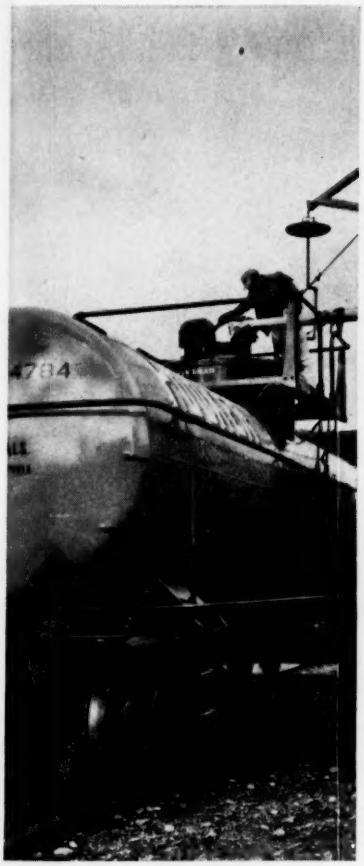
1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Service from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems

TIMKEN® *Fine Alloy* STEEL

TIMKEN ALLOY STEEL AND SEAMLESS TUBING IS AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

BRIEFS

benzoyl chloride in carboys or carloads
phosphorus oxychloride as a chlorinating agent
liquid caustic soda—which strength is right for you



BENZOYL CHLORIDE . . . BUY A CARBOY OR A CARLOAD

Any quantity of this Hooker compound assays 99% pure benzoyl chloride on a hydrolyzable chlorine basis.

It makes a fine carrier of the benzoyl group for Friedel-Craft reactions and as an intermediate for such chemicals as benzoyl peroxide, benzophenone, and benzyl benzoate.

It boils at 197.3°C., distills over a 3.5°C. range. Freezing point never goes lower than a minus 0.9°C.

For complete details on this versatile compound, just check and send the coupon.

PHOSPHORUS OXYCHLORIDE . . . INVESTIGATE IT!

It may pay you to look into this Hooker chemical if you're developing organic phosphates or plasticizers, gasoline additives, fire-resistant hydraulic fluids, or chlorinated products.

As a chlorinating agent, it neatly supplements and broadens your already wide choice of Hooker chlorine compounds. It's used also as a catalyst for intermediates and dyestuffs, and in the preparation of medicinals such as sulfa drugs.

For technical data sheet, just check the coupon.

50% TO 73% CAUSTIC SODA . . . DOES IT PAY TO SWITCH?

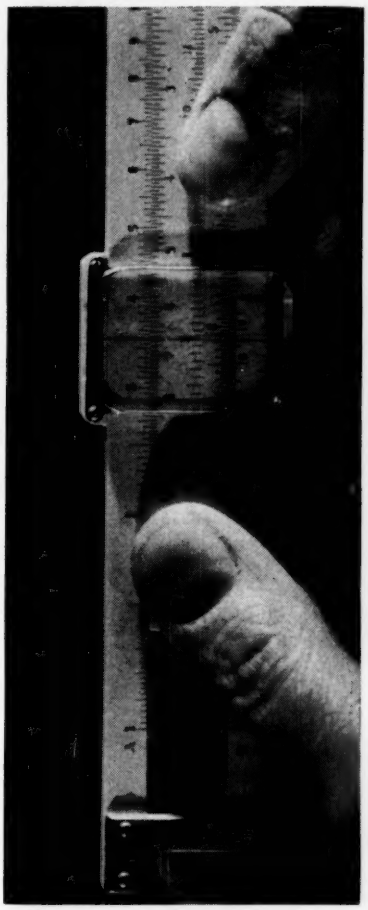
It depends.

Check your savings on freight for 73% caustic. Then subtract the annual depreciation on the dilution equipment you'll need.

If you still show a saving, it would be wise to consider the big switch seriously.

We'll be glad to help you survey the economics of 50% versus 73% caustic. Just send for a copy of our Caustic Soda Buyer's Guide. It contains a handy nomograph that helps you estimate possible annual savings on 73% caustic soda.

Our representative can help you with further details. Just write our nearest Hooker sales office.



For more information on chemicals mentioned on this page, check here:

- ☐ Benzoyl Chloride Data Sheet
- ☐ Phosphorus Oxychloride Data Sheet
- ☐ Caustic Soda Buyer's Guide
- ☐ Caustic Soda Data Sheet

HOOKER CHEMICAL CORPORATION
403 Forty-Seventh Street, Niagara Falls, New York

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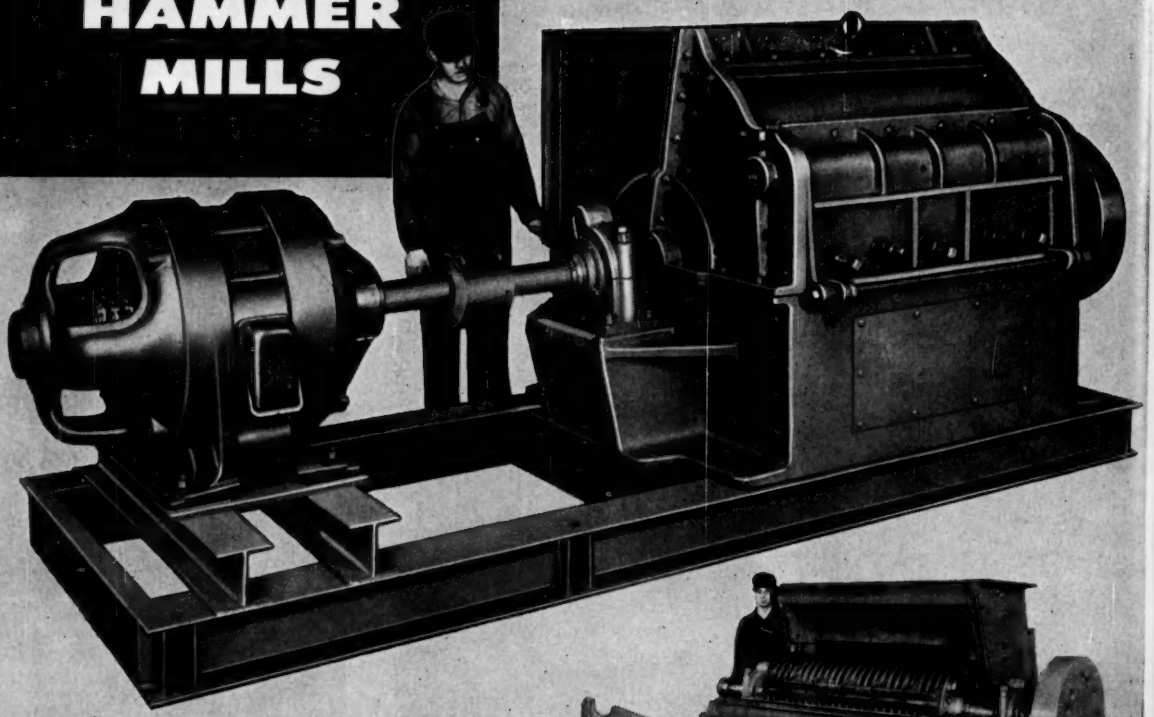
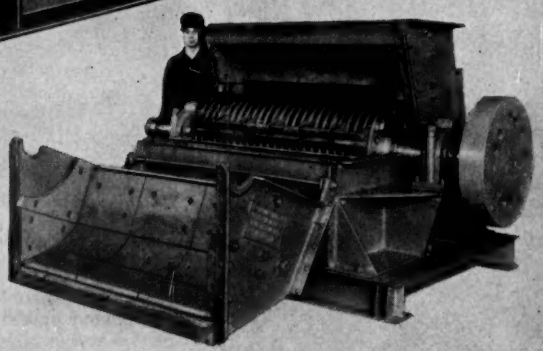
HOOKER CHEMICALS PLASTICS

WILLIAMS *heavy duty* HAMMER MILLS





- **Crushes, Grinds, Shreds To Finished Size In One Operation**
- **Reduces Production Costs Up To 50%**
- **Saves Up To 75% On Equipment Cost**

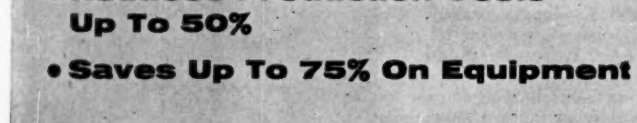
Williams No. 60 GA Mill with heavy duty steel plate frame. Cover has been opened to show heavy duty manganese steel liners, breaker plates, grate bars and hammers.

Whether your size reduction job involves crushing, grinding or shredding—whether the material is mineral, chemical, vegetable or animal—Williams has a hammer mill designed to *do it from start to finish in a single operation.* More uniform product, increased output, plus savings in time and labor can *cut production costs as much as half!*

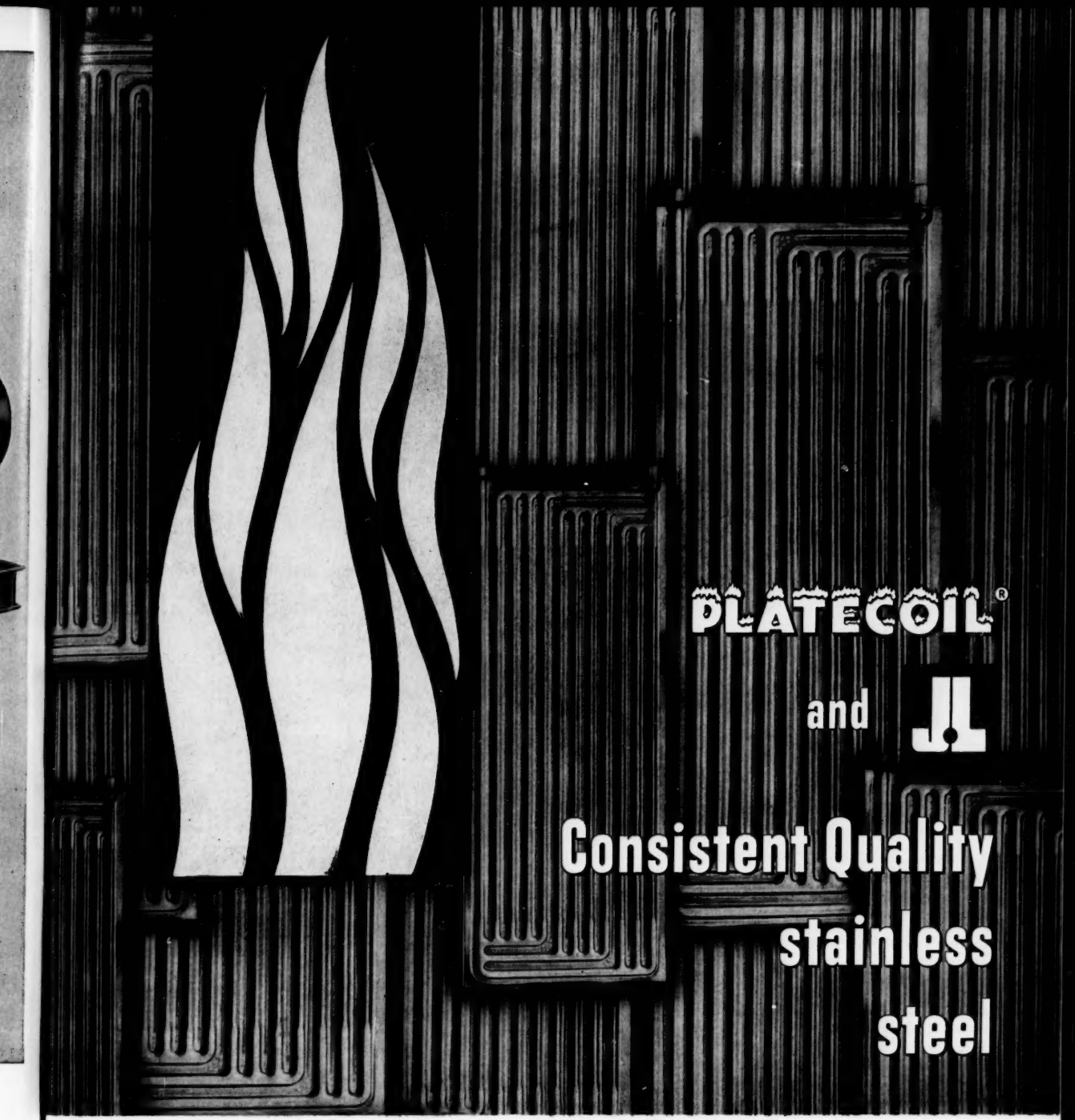
Extra primary and secondary crushers are seldom required with a Williams—no extra drives or conveyors, no costly foundations or buildings for additional crushers are necessary. Expensive maintenance, replacement parts, excessive downtime and labor are reduced to a minimum.

Learn how a Williams hammer mill can step up your output, and improve your product quality. *Write —explain your operation—and ask for a catalog.*

WILLIAMS PATENT CRUSHER & PULVERIZER CO.
2706 N. 9th St. St. Louis 6, Mo.



WILLIAMS
CRUSHERS GRINDERS SHREDDERS
Oldest and Largest Manufacturers of Hammer Mills in the World



Maintaining a constant temperature of 70 to 72° F in a 16⅔% sulfuric acid solution is an ideal application for Platecoil... typical of many engineered by Tranter Manufacturing inc., Lansing, Michigan.

Corrosive environments dictate the use of stainless steel, Tranter's rigid production requirements dictate the use of J&L Consistent Quality stainless steel.

Why J&L? Here's the reason given by Mr. M. C. Nolen, Tranter Purchasing Agent:

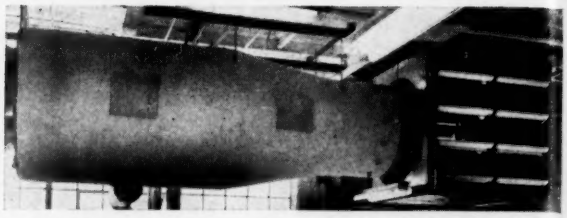
"Tranter uses J&L stainless because of its uniform quality. It takes all the headaches out of raw materials and makes our job a matter of just processing this superior product."

Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

J&L STAINLESS
SHEET • STRIP • BAR • WIRE

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • DETROIT 34

17 reasons why the Carrier Rotaspray Weathermaker System is



Carrier Rotaspray units may be installed rooftop mounted, ceiling suspended or outside wall mounted.

TODAY'S BIGGEST INDUSTRIAL AIR CONDITIONING NEWS!

1. Proved in use. Now in its fifth year of use in many different applications, the revolutionary Rotaspray® Weathermaker System* has proved itself vastly superior to conventional close-control systems.

2. Unitary design. Instead of one large conventional central station system serving several departments, each department has its own Rotaspray unit and can change its temperature and humidity to meet its individual needs.

3. Smaller apparatus size. A Rotaspray unit requires less than ⅓ the space of a conventional system of equal capacity, due to its high velocity design.

4. Reduces cleaning and maintenance costs. Rotaspray units, with exclusive self-cleaning design, require very little maintenance.

5. Needs no apparatus rooms. No rooms are required to house Rotaspray units, even when located outside a plant.

6. Lasts indefinitely. Rotaspray units, constructed of stainless steel, deliver a long life of trouble-free service—eliminate the need of cleaning and painting.

7. Eliminates many system components. Because of revolutionary system design, Rotaspray units need no water strainer, no water pump, no water tanks, no city water and drain piping, no apparatus room and no floor drains.

8. Needs no air filters. Instead of trying to keep dust and coarse particles out as conventional systems do, the Carrier system draws them in, separates them from the air and returns them to central point for automatic collection and disposal.

9. Better humidity and temperature control. By a new control method, the Rotaspray System eliminates dewpoint control and its problems. Within system capacity, departments simply "dial" the temperature and humidity required.

10. Low operating weight. Since Rotaspray units are smaller, require no enclosure, and have no standing water level, their weight is relatively low and units may be ceiling suspended or rooftop mounted without additional building reinforcement.

11. Constant air supply. Conventional systems use automatic dampers which close down and reduce the amount of air delivered to the room. Though this causes variations in temperature and humidity, it is a "must" in such systems to prevent excessive operating costs. With the Rotaspray System, air is always constant, yet operating economy is superior.

12. Longer fan life. In conventional systems, the fan is on the unit's leaving side where high humidities cause excessive corrosion. The Rotaspray unit, with the fan on the entering side where humidities are lower, greatly lengthens fan life.

13. Relocates easily to meet plant changes. Rotaspray units require no housing, are small enough and light enough to allow easy relocation.

14. Allows lower air quantities. Rotaspray Systems require from 5 to 10% less supply air than conventional systems. Result: better air distribution and smaller ductwork.

15. Eliminates "compromise" temperatures and humidities. With the new Rotaspray System, exact conditions can be maintained in each department. One area is not dependent upon another.

16. Install evaporative cooling now—simply add refrigeration later. When a conventional system is converted from evaporative cooling to dehumidifying service, many extensive modifications are required—such as the addition of chilled water lines, water storage tanks, etc. With a Rotaspray System, none of these must be added. Except for minor changes in the control system, the only need is the addition of a water-chilling machine.

17. Provides more at a competitive price. Though individual plant conditions vary, on the average you pay no more for a Rotaspray System than for conventional "high-quality" systems. And you get a lot more back in efficiency, economy of operation and maintenance savings. For information about the revolutionary Carrier Rotaspray Weathermaker System, write Machinery and Systems Division, Carrier Corporation, Syracuse 1, N. Y.

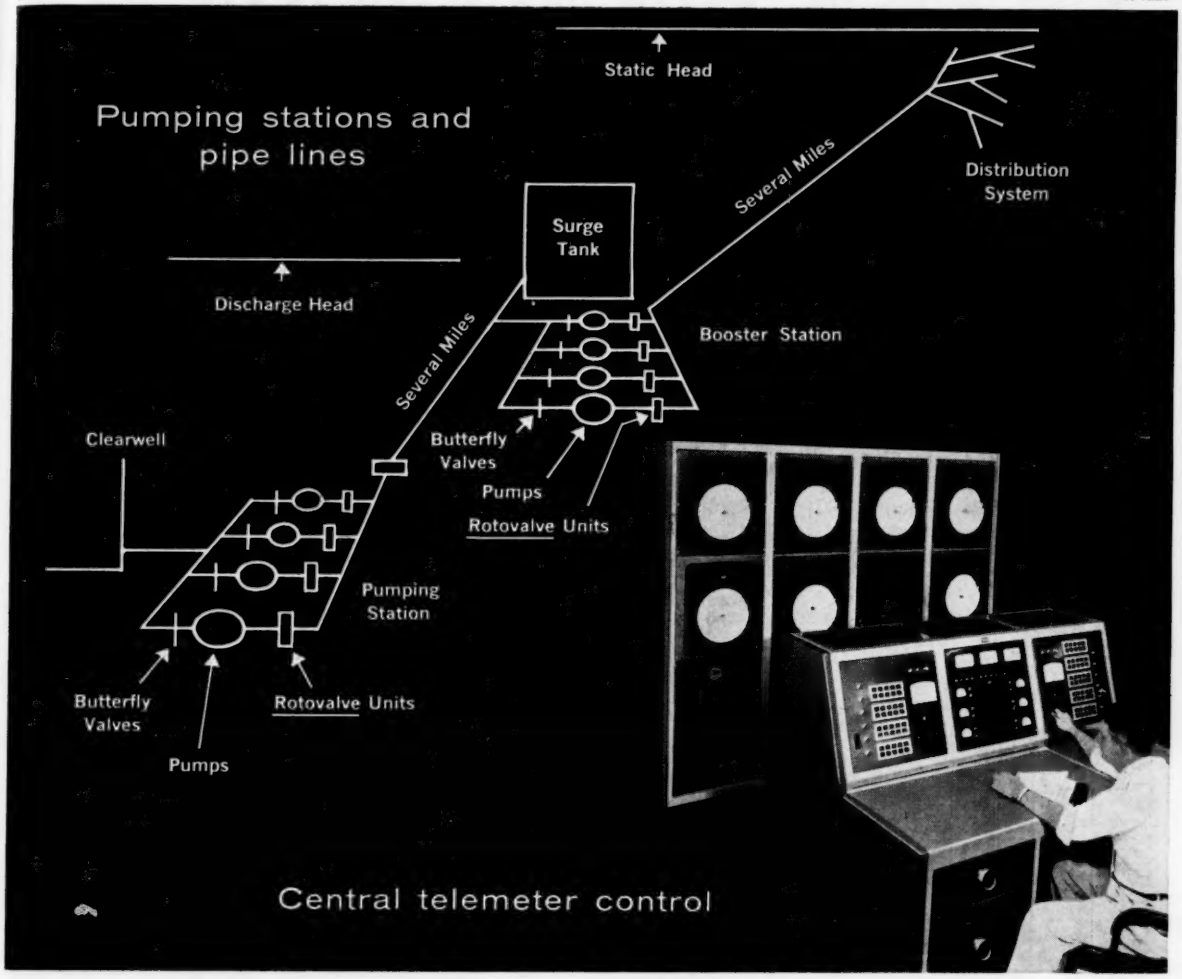
Pat. Pending

MORE PROOF OF
BETTER AIR CONDITIONING FOR EVERYBODY EVERYWHERE

Carrier

ALLIS-CHALMERS

A-1229



One man controls 60 mgd with

telemetered valving

Pumping stations operate completely unattended, controlled from a central remote console in this major water procurement and distribution system. Rated for 60-mgd peak load, it distributes over a 100-square-mile area from widely separated stations and storage tanks.

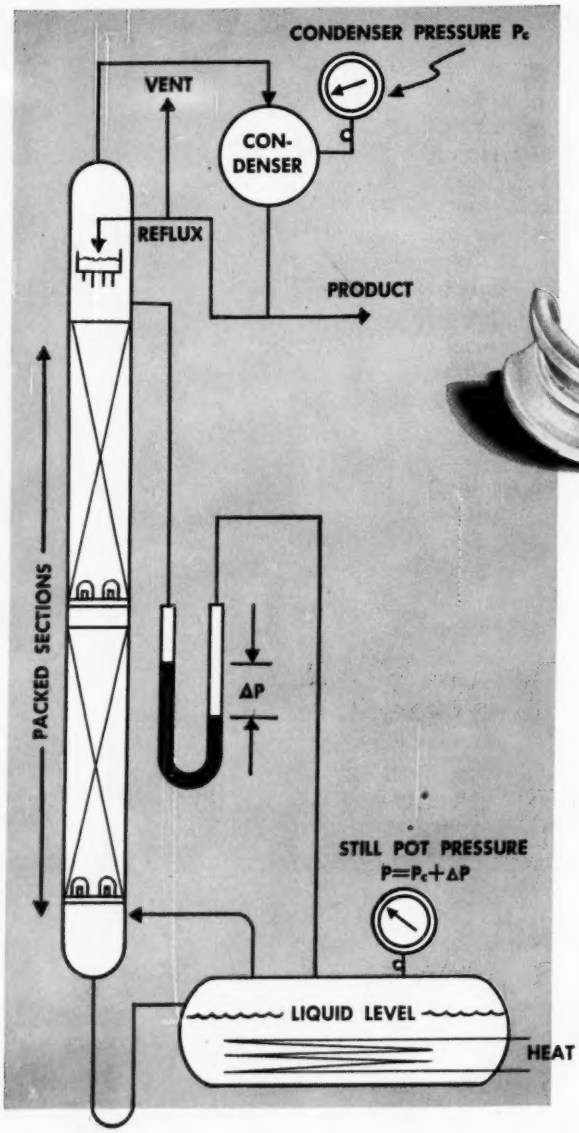
This is another dramatic example of complete valving service offered industry by Allis-Chalmers. Whatever you're dealing with, liquids or gases, including highest temperatures and pressures — Allis-Chalmers is your convenient source of today's most comprehensive rotary valve line. Types and sizes cover virtually every need . . . including *Rotovalve* units, butterfly and wafer valves and ball valves. We can also assist you in every phase of planning, engineering and installation. *Contact your Allis-Chalmers representative, or write* ***Allis-Chalmers, Hydraulic Division, York, Pa.***

Rotovalve is an Allis-Chalmers trademark.

Key to a superior valving system, Rotovalve **units offer the least pressure loss . . . ideal flow characteristic . . . controlled timing . . . positive seating . . . easy operation always.**

How to Lower Pot Temperatures in

VACUUM DISTILLATION



One of the important aims in vacuum distillation is to maintain as low an operating temperature as possible. High temperatures are injurious to many organic materials. Particularly, in batch operations, where virtually all the heat must be supplied to the liquid in the pot, losses due to pyrolysis can be substantial.

Temperature in the still pot depends on the pot pressure and pot pressure is the sum of condenser pressure and pressure drop through the packing in the tower.

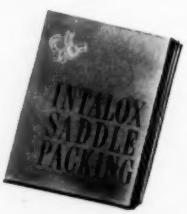
Intalox Saddle packing, with a pressure drop 60% to 65% lower than Raschig Rings, may permit reductions in pot temperatures up to as much as 50° F.

If you handle such organic materials as essential oils, fatty acids, pharmaceuticals, it will pay you well to use Intalox Saddle Packing in your distillation processes.

87F-1

Write for this booklet—

Bulletin S-29R-1 gives full information on Intalox Saddle Packing—packed with technical data every chemical engineer can use. Free on request
Write Dept. CE-360
U. S. Stoneware, Akron 9, Ohio.



U. S. STONEWARE
AKRON 9, OHIO

DEVELOPMENTS . . .

MARCH 7, 1960

Chementator

T. PETER FORBATH

American Cyanamid will acquire technology of Japanese firm Sumitomo Chemical's new cancer drug, Tespamin. Drug is claimed to be effective in treating mammary and uterine cancer.

Sites for third and fourth of Interior Dept.'s five water-desalting plants have been chosen. Webster, S. D., will get 250,000-gal./day electrodialysis unit; Roswell, N. M., 250,000-gal./day forced-circulation vapor-compression facility.

Air Force reportedly is seeking more hydrazine capacity in U. S., will call for competitive bidding shortly on a plant to be under construction later this year. Reason: Revitalized interest in hydrazine as rocket fuel. Currently, Olin Mathieson is only producer of material.

Synthetic-natural-rubber picture clears

Commercial activity in synthetic-natural rubbers is beginning to heat up. And as it does, the first clues to the technologies involved —especially in long-mysterious polyisoprene— are leaking out.

Goodrich-Gulf, now in advanced engineering on polyisoprene and polybutadiene, is sighting on a late-'61 startup date for a 25,000-ton/yr. plant at either Orange, Tex., or Institute, W. Va., to make both rubbers. Firestone, after years of pilot planting, has finally decided to move ahead with a 30,000-ton/yr. facility at Orange, Tex., also to produce both rubbers. Shell's 20,000-ton/yr. polyisoprene plant at Torrance, Calif., and Phillips' 20,000-ton/yr. polybutadiene plant at Borger, Tex., are nearing completion. And Goodyear, Montecatini and Texas-U.S. Chemical, among others are advancing their work with these rubbers towards commercialization.

Of the two rubbers, polyisoprene has raised the most questions. Chief among them: How do you make polymerization-grade isoprene monomer at a low enough cost—about 15¢/lb.—to produce polyisoprene at a price—about 30–35¢/lb.—competitive with other rubbers? *CE* has learned one answer to that question—Shell's. Company will get its high-purity isoprene by dehydrogenating high-purity isoamylene. Shell last month brought on stream a new plant at Torrance to cut isoamylene from a C_5-rich refinery stream, then purify it in two-stages of distillation featuring a 120-ft.-tall by 7-ft.-dia. column containing 50 Glitch Ballast trays. Polymerization of monomer takes place over a Ziegler-type catalyst.

There's another isoprene process making a serious bid for commercial attention. It's the Institut Francais du Petrole route that makes isoprene via the reaction of isobutylene and formaldehyde (*Chementator*, June 1, 1959, p. 35). A major U.S. process-design firm, *CE* learns, is offering the process in this country, indicates it will be announcing a buyer soon.

NOW IS THE TIME TO BUILD YOUR PHENOL PLANT

Thinking of producing phenol? Looking for the optimum investment in facilities? Today,

PROCESS ENGINEERING IS BETTER!

with its unequalled engineering-construction background of phenol-from-cumene projects, Kellogg can build a phenol plant at a considerably lower initial investment than five years ago.

INITIAL INVESTMENT IS LOWER!

Operating costs are also lower. As proved recently in the case of one major phenol producer, chemical manufacturers realize the ultimate economies of a Kellogg-built plant when the contract is on a turn-key

PLANT COMPLETION IS FASTER!

basis. Kellogg, in this instance, working closely with customer's engineers, was completely responsible for engineering, procurement, construction. The customer, for a lump sum, took over a complete plant—

OPERATING COSTS ARE LOWER!

producing phenol and acetone to specs. *within 14 months after the contract was awarded.* If a phenol plant is in your company's future, investigate *now* the time-and-money-saving advantages of Kellogg's turn-key approach.

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17

A subsidiary of Pullman Incorporated. *Offices of Kellogg subsidiary companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires*

But at the moment, most firms with immediate commercial polyisoprene plans, apart from Shell, tell *CE* that they plan to buy low-cost polymerization-grade isoprene. One very likely supplier is Shell. Others: Esso and Phillips, both manufacturers of low-grade isoprene for butyl rubber. Phillips tells *CE* that it's already supplying polymerization-grade isoprene for the pilot plants of firms now moving into commercial-scale polyisoprene manufacture but declines to reveal its process.

New natural-gas-treating route picked

A new solvent process for treating natural gas of uncommonly high carbon dioxide concentrations, developed by Fluor Corp., is just a short step away from commercialization. *CE* learns that El Paso Natural Gas is preparing to license the process for use in a 220-million-cu.ft./day gas-treating facility near Sheffield, Tex. Apparently all that's delaying completion of the deal is Federal Power Commission approval for construction of the plant.

If—more likely, when—FPC grants its okay, El Paso will move ahead with a $10-million expansion in the Brown-Bassett (Terrel County, Tex.) gas field. Expansion includes a gas-gathering system and a 51-mile, 20-in.-dia. pipeline. But the Fluor-process gas-treating plant, undoubtedly, is its key element. Reason: Gas produced from Brown-Bassett wells often contains as high as 53% CO_2, removal of which reportedly can be handled by the Fluor flowsheet more economically than any other currently available process.

Though Fluor isn't revealing technical details at this time, process has been described as a physical absorption using "very low" vapor-pressure organic solvents at near-ambient temperatures. Moreover, solvent is said to have low viscosity and hygroscopicity, be noncorrosive to common metals, nonreactive with all natural gas constituents (in El Paso's case principally methane, ethane and CO_2) and commercially available at reasonable cost.

What criteria for firing engineers?

What criteria must a company use when seeking to lay off an engineer who's a member of a collective bargaining unit? Can it evaluate him strictly on the basis of the specific job he is performing for the company? Or must it evaluate him on the basis of all the jobs that his education and experience seem likely to equip him to perform?

These questions go up for arbitration this month at that, by now, famous engineering union-management testing ground, Boeing Airplane Co. (Seattle), where some 8,650 engineers are represented by the Seattle Professional Engineering Employes' Assoc.

Incident under question: The firing of Richard F. Dortch, a mechanical engineer in Boeing's tooling department where the company has been forced to make personnel reductions for business reasons. Union contends that Boeing management didn't abide by the layoff procedure set forth in its labor contract with SPEEA. Boeing maintains that it did. Attorneys for the principals will file their arguments with a three-man arbitration board next week. And a decision is expected by April 1.

Key point over which the debate came to loggerheads during three days of preliminary hearings last month was interpretation of a clause in the Boeing-SPEEA contract that dates back to 1946. Clause requires that, before an engineer can be laid off, "determination of his ability shall be made by a management review committee based on full consideration of performance, educational and experience records of all employees employed in occupations wherein a reduction is to occur, and by comparing such records with the records of employes in the same or related occupations within the bargaining unit." After this comparison "management shall determine which employes shall be retained."

Boeing maintains that it followed correct procedure by comparing Dortch's record with the other mechanical engineers in its tooling department. And it found that he had the lowest rating of all engineers employed there.

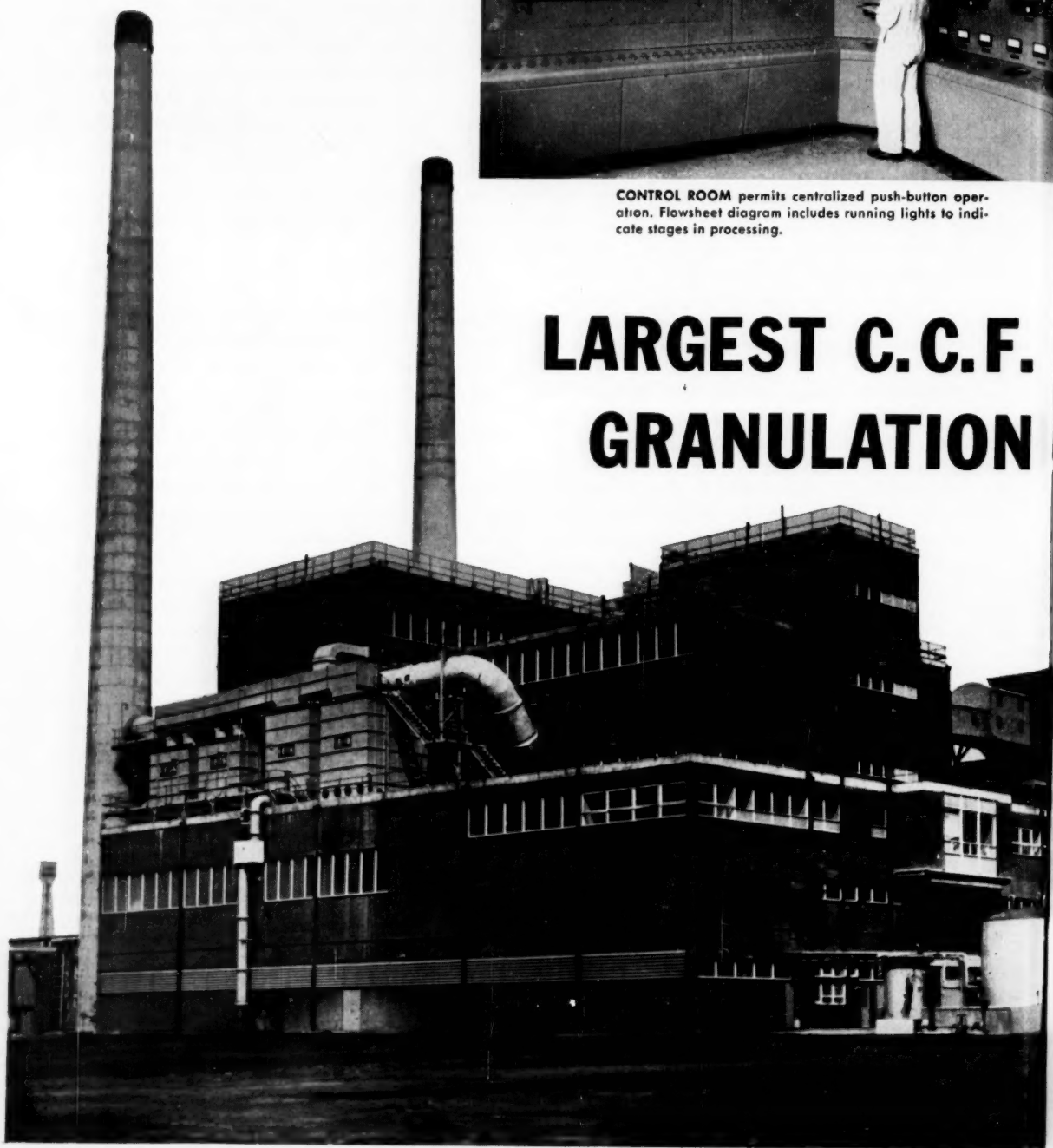
SPEEA rejoins that Boeing management should have compared Dortch with all mechanical and structural engineers throughout the entire Boeing engineering organization and laid off the engineer with the lowest rating on this basis. (It wouldn't have been Dortch, last month's hearings indicated.) Union's reasoning: An engineer has the "mental capacity to solve new problems" as testified by the fact that the average Boeing engineer gets a new assignment every six months. Thus, a mechanical engineer from another department with a lower rating than Dortch should have been

(Continued on page 56)

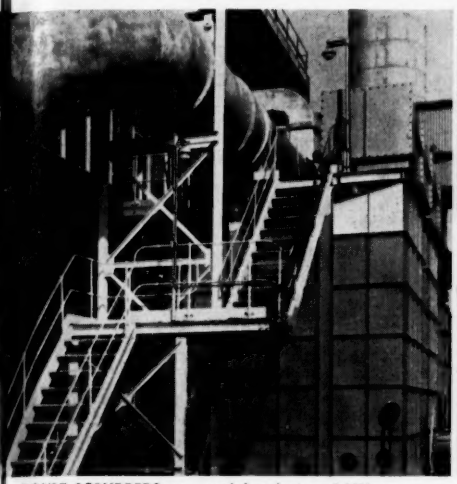
Designed by DORR-OLIVER for I

CONTROL ROOM permits centralized push-button operation. Flowsheet diagram includes running lights to indicate stages in processing.

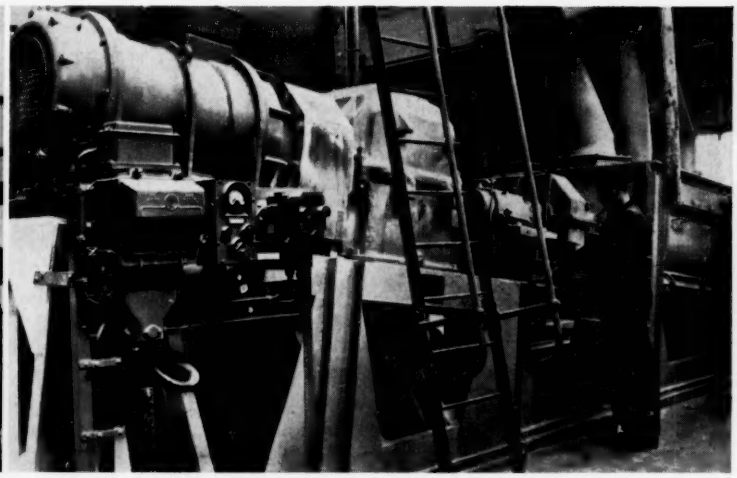
LARGEST C.C.F. GRANULATION P



Imperial Chemical Industries Limited



DOYLE SCRUBBERS are used for dust and NH_3 recovery and for cooling and condensation to minimize visible stack effluent.



DORRCO BLUNGER (2 installed) mixes fertilizer chemicals and starts granulation process, which is completed in large rotary dryers. Photo shows drive and feed end.

(Concentrated Complete Fertilizer) PLANT in the British Commonwealth

The more than 40-year-old experience of the Dorr-Oliver organization in designing or equipping nearly 50 fertilizer projects in 17 countries has been utilized in another spectacular development—the largest C.C.F. granulation plant in the British Commonwealth and one of the largest in the world.

The plant is the latest addition to the immense 1100-acre chemical complex operated by Imperial Chemical Industries Limited at Billingham, England. Sulphate of ammonia, monoammonium phosphate and muriate of potash are combined by the Dorrco Granular Fertilizer Process to form a concentrated complete 12-12-18 fertilizer. The two processing units comprising the plant produce a total of 1100 tons per day. Thanks to advanced design and extensive use of instrumentation, high productivity is achieved with a relatively small labor force for operation and maintenance.

Examples of recently completed projects, in addition to the Billingham installation, include plants for The American Cyanamid Company at Brewster, Florida; Scottish Agricultural Industries Ltd., Leith, Scotland; W. R. Grace Co., Davison Chemical Division, Bartow, Florida, and The Olin-Mathieson Company at Pasadena, Texas. If you are interested in the field of fertilizer production, why not call Dorr-Oliver for a preliminary discussion, or write for information to Dorr-Oliver Incorporated, Stamford, Connecticut?

The services of Dorr-Oliver cover all phases of plant design, from economic analysis to flowsheet preparation, construction, supply and installation of equipment and supervision of initial operation.

DORR-OLIVER

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

Dorrco – T.M. Reg. U.S. Pat. Off.

laid off and Dortch transferred to that department as a replacement.

Giant solid rockets on the way

One major drawback of solid propellant rockets—that they can't, practically, be built as big and powerful as liquid propelled versions—is beginning to crumble in the face of persistent engineering and research.

• North American Aviation's Rocketdyne Div. (McGregor, Tex.) finds that polybutadiene-based propellants "assure feasibility" of 2-million-lb.-thrust solid rocket motors. Improved physical properties of these propellants (over polyurethane, for example) permit them to withstand brutal stresses set up in the giant engine—15-ft.-dia. by 66-ft.-long containing 360 tons of propellant—that would be required to provide this hefty thrust.

• Aerojet-General (Sacramento, Calif.) reports plans to build a "multi-million-lb.-thrust" solid rocket using a segmented design. Company visualizes a rocket, standing some 60–70 ft. high and as much as 13 ft. in dia., made up of a number of sections each capable of generating 1 million lb. thrust. Though declining to specify details of design, Aerojet declares that the building-block concept has been proved out in model-scale rockets.

• United Research Corp. (Menlo Park, Calif.) has filed patents on a "unique segmented rocket-engine design" that will permit manufacture of engines with thrusts in the million-lb. class at a "fraction of the cost of comparable liquid engines."

Currently, the largest-thrust rockets are liquid propelled; the Atlas and Titan missiles deliver 380,000 lb., the planned inter-planetary multi-stage Saturn is rated at 1.5 million lb. thrust.

LTC unit to fuel novel power package

Though low-temperature coal carbonization (LTC) is having a tough time carving a commercial niche for itself in chemicals manufacture, it now seems likely to score in an entirely different field—electrical power generation. Ohio Power, working with General Electric, reports it's installing a GE-designed LTC unit to supply a substantial portion of the fuel for a novel steam turbine-gas turbine power package at its Beverly, Ohio, coal-fired electric generating plant.

Here's what's involved in this innovation-packed installation, due on stream next year. A 5,000-kw. gas turbine will be coupled to a 215,000-kw. steam turbine in a combined electrical generating cycle. Coal will be fed to the 800–1,200 F. carbonizing unit and cracked into coal gas and char. Gas, which includes the vaporized liquid products that are usually the desired end products of LTC units, will serve as fuel for the gas turbine. Char and gas-turbine exhaust will be used as fuel in a waste-heat boiler to generate a portion of the steam required by the steam turbine. Remaining steam will come from a conventional pulverized-coal-fired boiler.

Reason for this hookup: To boost thermal efficiency of power station by exploiting superior operating efficiency of gas turbines. Presently planned installation is described as a prototype. But, declares GE, it will prepare the path for fully commercial facilities—e.g., hookups using 22,000-kw. gas turbines—that will up power plant efficiency by 4%. While this may not sound like a lot, explains a GE spokesman, it represents a tremendous saving for an electric utility. "Considering that a utility spends almost as much for coal each year as it paid initially for building its power station, 1/10% saving is regarded as good."

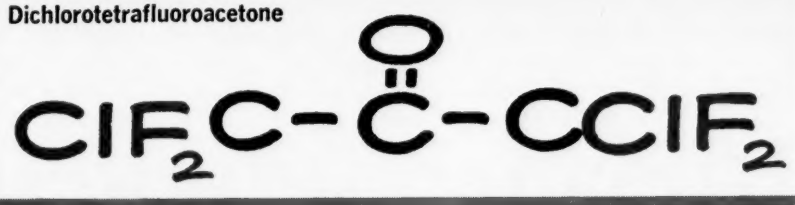
American Electric Power's Crisp County Station in Warwick, Ga., is only other utility known to have tried the gas-turbine, steam-turbine combination. But it uses natural gas to fuel its gas turbine. Ohio Power's use of LTC-derived coal gas represents a significant economic advantage because coal is considerably cheaper than natural gas.

New tire-cord battle: Nylon-6 vs. 66

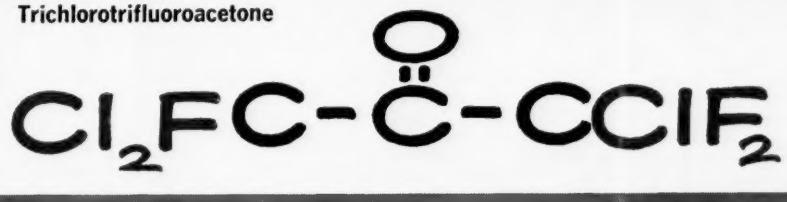
Two developments last month—Dow's announced plan to enter nylon-6 tire-cord manufacture, Chemstrand's start on a hefty expansion of nylon-66 tire-cord output—may signal the opening bell of a brand new round in the fierce tire-cord battle that has been raging for the past few years. Say many industry observers, these moves are sure signs that nylon is well on its way to driving rayon out of tire cord entirely, that the coming fight for that $300-million/yr. market will be between nylon-6 and nylon-66.

Right now rayon commands better than 98% of the original-equipment tire market. But nylon has been making giant inroads into the replacement-equipment tire market, already has wrested about 50% of it away from

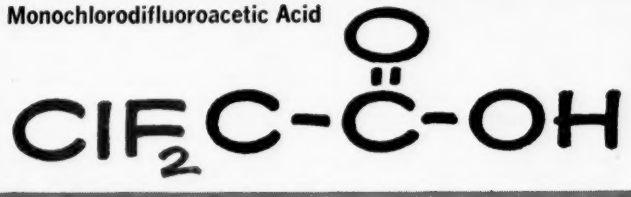
Dichlorotetrafluoroacetone



Trichlorotrifluoroacetone



Monochlorodifluoroacetic Acid



Now ready for your investigation...

THREE HIGHLY REACTIVE FLUORO ORGANICS

from the research laboratories of General Chemical, leader in fluorine chemistry

In its investigations of fluorine-containing acetones, General Chemical has developed and now offers experimental quantities of two promising ketones and a powerful acid:

1. **Dichlorotetrafluoroacetone**
2. **Trichlorotrifluoroacetone**
3. **Monochlorodifluoroacetic acid**

These fluoro organics have demonstrated unusual reactive capabilities which suggest a variety of possible applications including use as complexing agents, catalysts, and raw materials for fluoro-organic synthesis.

The ketones can be hydrated, alcoholated and ammoniated. They are stable in acid but react with alkalis to form derivatives of monochlorodifluoroacetic acid. They form amine and urea complexes and show interesting pyrolytic reactions.

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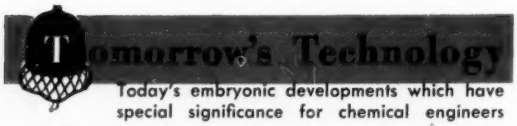
rayon. And there's widespread conviction now that, not only is nylon sure to take over the entire replacement market, it will eventually grab off the whole of the original-equipment market as well. Basis for this view: Several top tire manufacturers, *CE* learns, now are planning to switch to nylon yarn exclusively because of "definite knowledge" that major auto makers intend to start naming nylon-cord tires as original equipment on new cars within the next three years.

Chemstrand is gearing up for that day with plans for a 50% expansion of its present 124-million-lb./yr. nylon-66 capacity at Pensacola, Fla., and Greenwood, S. C. Dow's pitch for the tire-cord market takes the shape of a 12-million-lb./yr. nylon-6 plant slated on stream late in '61 at Williamsburg, Va. Company has licensed the H. Zimmer Co. (Frankfurt, Germany) process, will get caprolactam raw material from its new affiliate, Dow Badische Chemical (Freeport, Tex.).

Though presently 90% of all nylon cord marketed is the 66 variety produced by Chemstrand and Du Pont, Dow's move is another in a growing list that indicates nylon-6 is a fast-strengthening competitor. Allied introduced nylon-6 tire cord only last year. Since then Firestone, Beaunit, Dow have followed and others are known to be seriously considering such a move, too.



Man-made diamonds for transistors?

Latest outfit to join the swelling throng of diamond makers (*Chementator*, Dec. 14, 1959, p. 71) is the U.S. Air Force. But unlike the others, USAF, which disclosed last month that its Air Force Cambridge Research Center (Bedford, Mass.) has developed its own route to the coveted stones, is not after the industrial abrasives market. Rather, it's seeking to produce gem-quality diamonds with semiconductive properties for use in transistors and other electronic applications.

Though inescapably higher in cost than such baser materials as silicon or germanium, diamond transistors are attractive to AF researchers because of their incomparable heat resistance and all-around ruggedness. They would be ideal, for example, in electronic systems on space vehicles and in nuclear reactors. As yet, however, this is still several years away, an AF spokesman concedes. But a significant first step in that direction has been taken with the discovery of how to make diamonds with semiconductive properties, he stresses. In nature, diamonds of such properties are found only with great infrequency.

Process AF has come up with, superficially at least, is not unlike General Electric's. Only apparent difference between the two is choice of high-pressure machinery. Whereas, GE uses a doughnut-shaped chamber into which conical pistons push, AF employs a 7.5-ft.-tall, 8.5-ton tetrahedral anvil press. Graphite and nickel catalyst are subjected to around 1.8 million psi. and about 2,300 F. with heating accomplished electrically.

To explain why its process turns out stones with semiconductive properties while GE's doesn't, AF only says that GE, seeking industrial abrasives applications for its products, "forces" its diamond to have highly abrasive character.

Research and development briefs

New high-pressure measuring device has been designed by Harwood Engineering (Walpole, Mass.). Called a bulk modulus cell, unit measures pressures from 0 to 2 million psi. Cell body consists of a thick-walled steel cylinder into which is fitted a hollow cylindrical steel probe open at one end. Probe is held in place by a threaded retainer which also serves to compress packing between shoulders on cell body and probe. A stem projects from inner end. When subjected to hydrostatic pressures, probe contracts and contraction is measured by motion of stem.

Nondestructive hardness testing of steel can be accomplished by translating magnetic-induction data into mechanical data, claim Russians. Test pieces, magnetized to saturation, are dropped through fixed-length (33.15 in.) vertical pipe. During fall, they gradually lose magnetic properties and "hardness characteristics of samples are established by induction measurements at lower end of pipe." Special conversion system translates this information into mechanical data directly.

For more on DEVELOPMENTS.....60

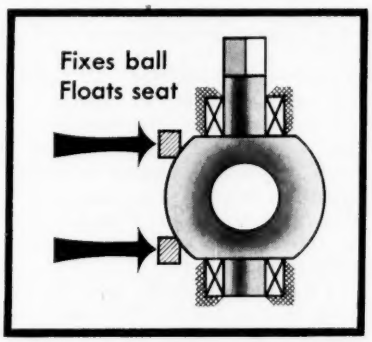
Can A Ball Valve Operate, Cycle After Cycle, With No Maintenance At All?

Read this remarkable answer, and discover an amazing engineering feat.

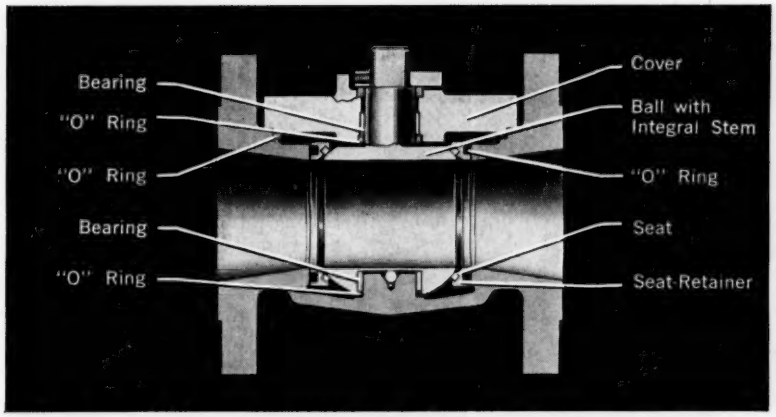
As most engineers know, ball valves offer a number of distinct advantages over all other types of valves . . . 90° on-off, minimum pressure drop, positive on-off indication, no lubrication, and compactness. In common with other valves, however, the design was insufficient to overcome the problem of continual maintenance.

Four years ago, this problem was faced by Hydromatics, Inc. in the valves that they produced for use in missiles, aircraft and ground support systems. Then, as today, all other ball valves were built with a ball that floated in its socket, and sealed by being forced against its seat by the pressure in the line. This caused seat distortion which made early replacement necessary.

Hydromatics tried a different approach. Rather than use the traditional floating ball, their engineers fixed the ball in bearings.



In the bearing-fixed **FLO•BALL** valve all pressure forces exerted on the ball are transmitted to low-friction bearings, thus eliminating down-stream seat distortion due to ball load. The pressure balanced seat, with its teflon sealing surface, is continually self-adjusted by the O-ring in the seat retainer.

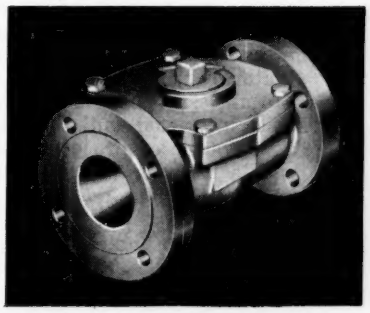


This O-ring acts as a self-energizing force that keeps the teflon seat always in contact with the ball. This insures positive sealing without seat distortion, and minimizes seat-resisting frictional forces. The combination of these low frictional forces results in low operating torque and extremely long seat life.

The bearing-fixed **FLO•BALL** valve proved itself immediately. Hundreds of missile and spacecraft systems, previously impossible, were made possible with these valves. The X-15, America's first manned space vehicle, for instance, has a Hydromatics **FLO•BALL** valve at its heart. Since its inception, the **FLO•BALL** has been used in more varied applications than all other ball valves combined.

Now, after the toughest application testing in history, bearing-fixed **FLO•BALL** valves are being mass produced for industry. They are available for off-the-shelf delivery to standard ASA dimensions in semi-steel, carbon steel, stainless steel, and aluminum. They operate at pressures to 600 psi, temperatures to 400°F and hold vacuum to 10^{-6} mm. of Hg!

The bearing-fixed **FLO•BALL** offers extra ball valve advantages. Top loading for easy access without removing the valve from the line, plus three features that are absolutely unique! Self-adjusting seats which automatically compensate for wear, proportional sealing force which automatically increases with line pressure, and the lowest torque, by far, of any valve. These combine to make the **FLO•BALL** valve virtually maintenance-free!



How long does it last without maintenance? Frankly, we don't know, since the first valves we ever built are still going strong and outlasting other valve types by more than 10-to-1. But don't take our word for it. See for yourself. Call, write or TWX for further information.

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DEVELOPMENTS . . .

PROCESSES & TECHNOLOGY

C. S. CRONAN

Filter Plant Removes A-Bomb Fallout in River

Radioactive fallout from U. S. and Soviet nuclear weapons tests, whether or not enough to constitute a hazard to human health as has been vigorously debated, has turned out to be a problem for one specialty-paper maker. Reports Knowlton Bros. (Watertown, N. Y.), A- and H-bomb testing in the past has sufficiently contaminated the firm's source of process water, the Black River, to make it unusable "as is" in the manufacture of papers used to package light-sensitive photographic materials and films. Hence, need for the filter plant shown in the picture above.

Company president David Knowlton explains that his firm's products serve in prolonged contact—up to two years—with camera-roll film, X-ray and other special films. Thus, even the "most minute amounts of radioactivity" in the packaging paper would result in defects in those films. Level of radioactivity far less than that emitted by the luminous dial of a wrist watch would ultimately destroy the worth of photosensitive materials.

Filter facility purifies 1 million gal./day of Black River water on a 24-hr. basis, lowers radioactivity level of river water to the point where it's useable in Knowlton's paper-making process. Filter tank measures 50 ft. dia. by 15 ft. deep, holds 180,000 gal. during the filtering process. Water flows through the tank as alum and powdered clay are added to it. Chemicals precipitate impurities from the water and, in this fashion, remove any radioactive particles present.

One unique feature of the filter tank is its redwood frame roof. A geodesic sphere, dome has no interior supporting trusses or posts. The lightweight members of the supporting globe hold the entire roof load.

New Polymer Aims to Invade Printing Field

A new type of photosensitive plastic will be making inroads into the photoengraving market—traditionally the exclusive domain of metals—if Du Pont hopes pan out. Du Pont is moving ahead with plans for a commercial unit at Parlin, N. J., to turn out 1 million sq. ft./yr. of "Dycril" photopolymer printing plates, with production slated to start in mid-1961. Reportedly Time, Inc., is working on a similar development.

Dycril plates consist of a thin layer of a light-sensitive (and unidentified) monomer bonded to a metal support. On exposure to ultraviolet light, the material polymerizes, becoming hard and insoluble. To produce a printing surface, a negative is placed over the plate and exposed to a strong ultraviolet light. Portions of the plate covered by light areas of the negative become hard while the dark areas remain unaffected. Washing with a pressurized water stream containing less than 1% NaOH removes unpolymerized material, leaving a raised printing surface. Plates ready for a press run can be made in 15-20 min., considerably faster than current acid engraving procedures.

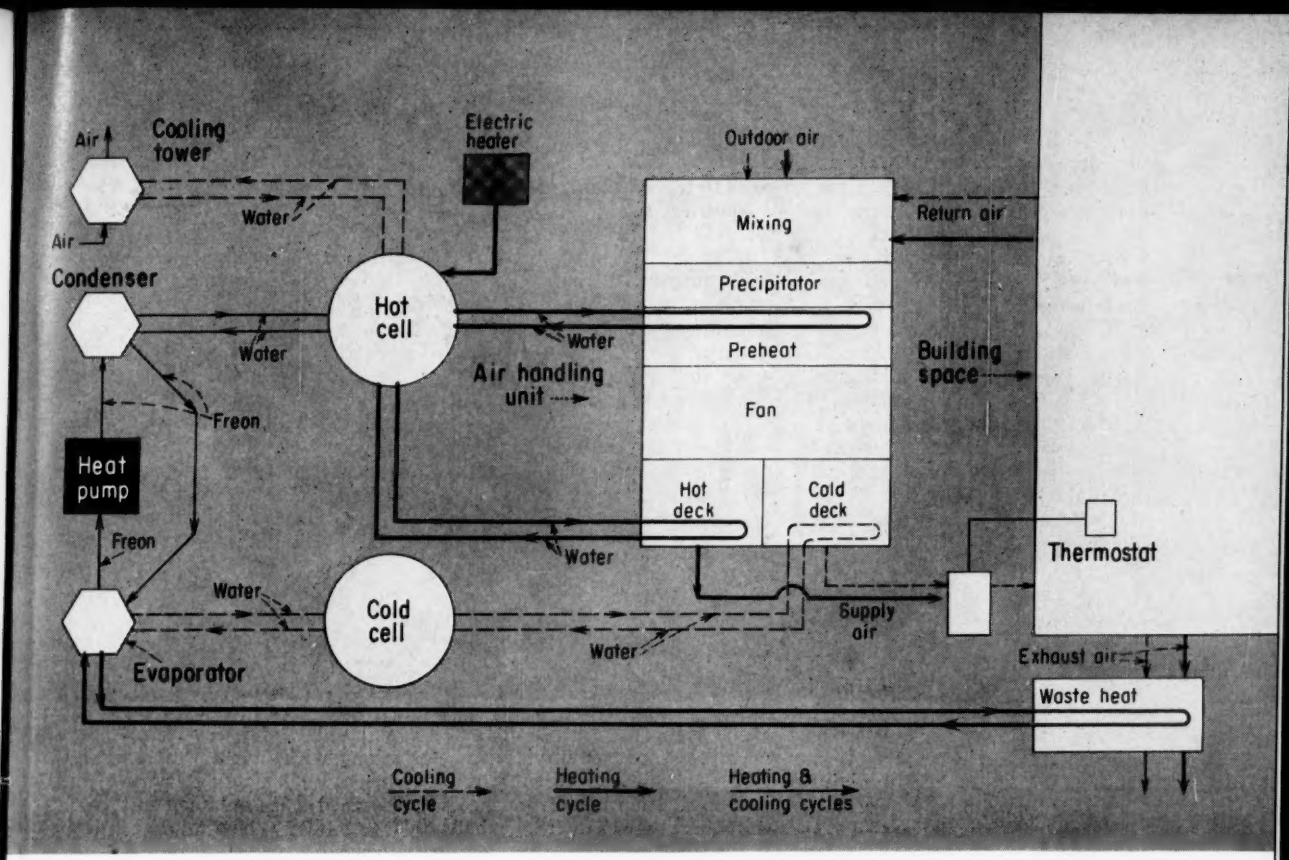
Initial cost of the plastic plates will be about $10/sq. ft., higher than competitive metal plates. But Du Pont expects that greater speed in making plates plus the reduction in make-ready press time will justify the higher initial cost in many engraving shops.

Dycril has been undergoing field tests since 1957 and Du Pont says it has already invested $6 million over a 10-yr. period developing the new material. To supply demand until full production is under way, firm is doubling capacity of its Parlin pilot plant.

New Firm to Publish Unique Chemical Index

Declaring that "Soviet scientists make more use of American research information than we do," Eugene Garfield announced formation of the Institute for Scientific Information at 1122 Spring Garden St., Philadelphia 23, Pa. Institute director Garfield says that the organization "will attack all phases of the scientific information bottleneck through a unique program keyed to the specific requirements of research scientists."

First project of the new institute is the *Index Chemicus*, a register and index of the more than 50,000 new chemicals synthesized each year throughout the world. Another plan in the works is a program for disseminating scientific information in space and missile research. Discussions of this program are already under way with government space officials.



Pump Balances Space Heat in New Facility

Here, in one of the first industrial installations, is how a heat pump enables a company to condition building space more effectively throughout the year.

Right out of the pages of your old thermodynamics text into reality comes Victor Chemical Works' latest answer to a space heating problem.

At its new Applied Research Laboratory, Chicago Hgts., Ill., Victor uses Kelvin's heat-pump principle to heat and air condition building space. Heat pump displaces both the traditional furnace and air conditioner to provide an economical, comfortable working atmosphere for Victor researchers all year round.

▶ **Locking In the Heat**—Originally, Victor engineers included the heat pump in the lab layout to conserve exhaust heat from testing ovens and hoods. To maximize recovery of this heat, Victor designed its lab to minimize heat loss through use of super-efficient insulation.

By combining conservation and recovery of heat, Victor returns 5 therms/hr. (1 therm = 100,000 Btu.) to the building space via the heat pump. Heat generated by lights, people and equipment add another 2.5 therms/hr. Balance needed to satisfy total requirement of 9 therms/hr. comes from auxiliary electric resistance heater.

Walls, which are unbroken by any windows, are built 15-in. thick with special concrete block and 2-in. thickness of foamed glass insulation sealed with asphalt emulsion to lock heat into building. Cheerful interior decoration and bright lights compensate for missing windows.

With this type of construction, Victor has actually reduced overall coefficient of heat transfer to 0.14 Btu.(hr.) (sq. ft.) (°F.). Even with a total system failure on a 0-F. day, temperature will drop less than 1 deg. F./hr.

▶ **Air on the Move** — Key to maximum utilization of heat is

to circulate air continuously through the building, hence redistribute it where it's needed most. Lab is divided into several heating zones, each with its own heating or cooling load and separate air ducts.

Here's how heat flows for maximum winter heating. Cold outdoor air (estimated minimum −10 F.) flows through an electrostatic air cleaner, then enters an air heating unit. Latter consists of two decks of ducts, one hot duct (110 F.) and one cold duct (50 F.) for each zone. Hot ducts contain hot-water coils; cold ducts contain cold-water coils.

To satisfy winter heating, most of the air flows through the hot deck. Split of flow through hot and cold ducts is controlled separately for each zone according to its respective heating or cooling load. Air streams from hot and cold decks join in mixing boxes and flow to lab zones.

▶**Recovering Hood Heat**—Hood exhaust from each zone contains useful heat, generated by ovens and burners. Construction of hoods is designed to minimize leakage of heat directly back into lab, delivers it instead via ducts to a heat exchanger.

In this heat exchanger, consisting of an insulated tower equipped with copper coils, heat transfers from the hot air to water which flows through the coils.

▶**How Pump Heats**—From the exchanger, heated water flows to the heat-pump evaporation unit. Here, heat from the water evaporates liquid refrigerant (fluorinated type).

Then a pair of 30-ton compressors add work to the refrigerant gas; compressed gas flows to condenser where it transfers heat of compression and vaporization to water during condensation. Water loop then carries heat to hot cell and from hot cell to hot deck.

For maximum winter heating, seven 10-kw. electrical-resistance heaters provide auxiliary heat to the hot cell.

▶**How Pump Cools**—For summer operation, the opposite end of the heat cycle goes to work. Water, at nearly ambient temperature, flows through the refrigerant evaporator where it is cooled to 45 F. Cooled water flows to the cold deck coils where it cools hot outside air to a comfortable 70 F.

Heat, picked up by the refrigerant, goes through the heat pump cycle. In the condenser, this heat transfers to a water circuit.

An indoor cooling tower contacts a stream of outside air with a spray of the heat-laden water, cooling it by evaporation. Discharging from the tower, the air carries the heat out of the building. Cooled water recycles from the tower back to the refrigerant condenser, along with makeup water.

So, you see that, in the summer, the heat pump operates just as it does in the winter by evaporating, compressing and condensing the refrigerant in the same sequence. But in the summer, the heat pump is merely operating in a different circuit set up to strip heat from incoming air rather than from exhaust air. Heat added to air within the building is purged by discharging hood exhaust directly to atmosphere.

Radioisotopes Save Agricultural Dollars

Casting another vote in favor of the future of radioisotopes, Stanford Research Institute recently completed a study of the dollar-saving role that isotopes play in agricultural research. SRI estimates in its report, "Radioisotopes at Work for Agriculture," that minimum savings as the result of agricultural use of isotopes will amount to $180-million during the next 20 years.

Basis of seemingly optimistic estimate is increase in farm productivity due to isotope's role in promoting plant growth and in breeding more fruitful plants. "One of the surest ways of increasing food production is to control mutations and develop more fruitful plants," points out C. L. Comar, director of Cornell University's Radiation Biology Lab. And hundreds of other university, private institute and testing station researchers affirm estimated savings in their report to SRI.

Reporting researchers point out radioisotope's indispensable role in laboratory and field studies of irrigation, soil composition, plant physiology and pathology, insect control and veterinary physiology. Researchers employ radioisotopes as tracers to measure flow profiles and make diffusion studies, as labeling compounds in physiological studies and as radiation sources for activation analysis.* Use of isotopes permits reduction of research time, simplification of research procedure and development of otherwise impossible research procedures.

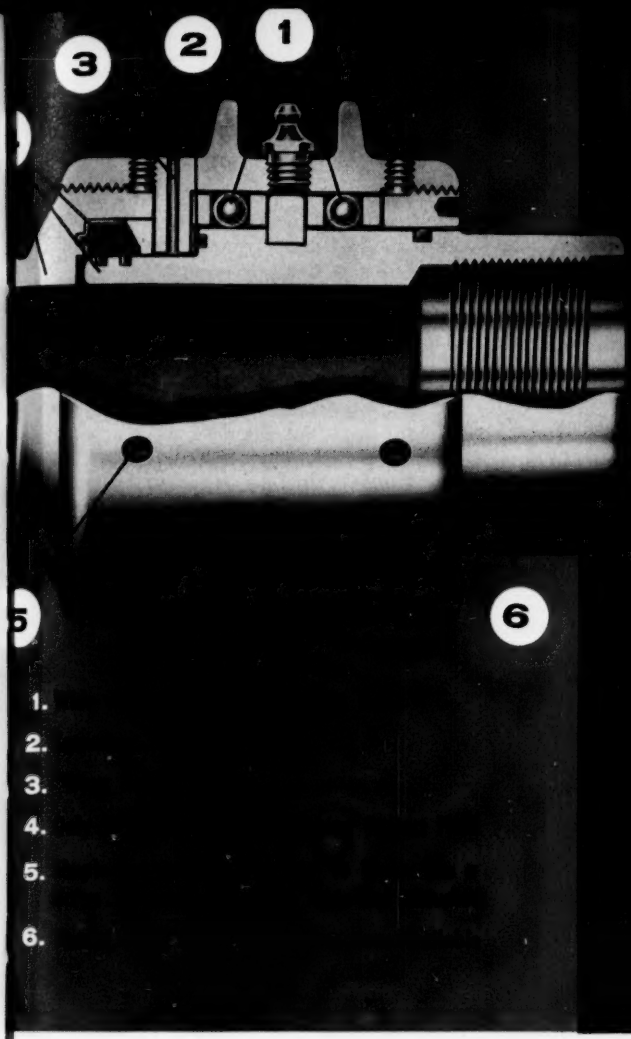
SRI's report forecasts a great increase of consumption of isotopes for agricultural use in the next few years; radioisotope suppliers listen happily to this news along with industry's tidings of increased demand. Because of increased sales volume, unit costs are already beginning to drop (*Chem. Eng.*, Nov. 16, 1959, pp. 100-104) and should continue to do so.

Only limitation to the future of radioisotope application seems to be the lack of training facilities for research personnel. At present the only schools equipped to teach personnel the techniques of radioisotope handling are Oak Ridge and Harwell.

* A quantitative analysis technique described in "Radioisotopes for Industry" by Rochlin and Schultz, (Reinhold Publishing Corp).

Czech Acetylene Process Claims Highest Yields

From the Institute for Petroleum Research in Brno, Czechoslovakia, comes a report of a new process for making acetylene and ethylene from hydrocarbons in an a.c. electric arc. Research engineers claim that total yields of acetylene and ethylene, based on methane feed, run around 58%. By comparison, the Chemische Werke Huels electric-arc plant in Germany (the only commercial electric-arc acetylene process in the world) is believed to get 40-45% yields. And the partial oxidation processes only get about 30% yields with methane;



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..are repaired on location with simple tools

..can be welded into the line

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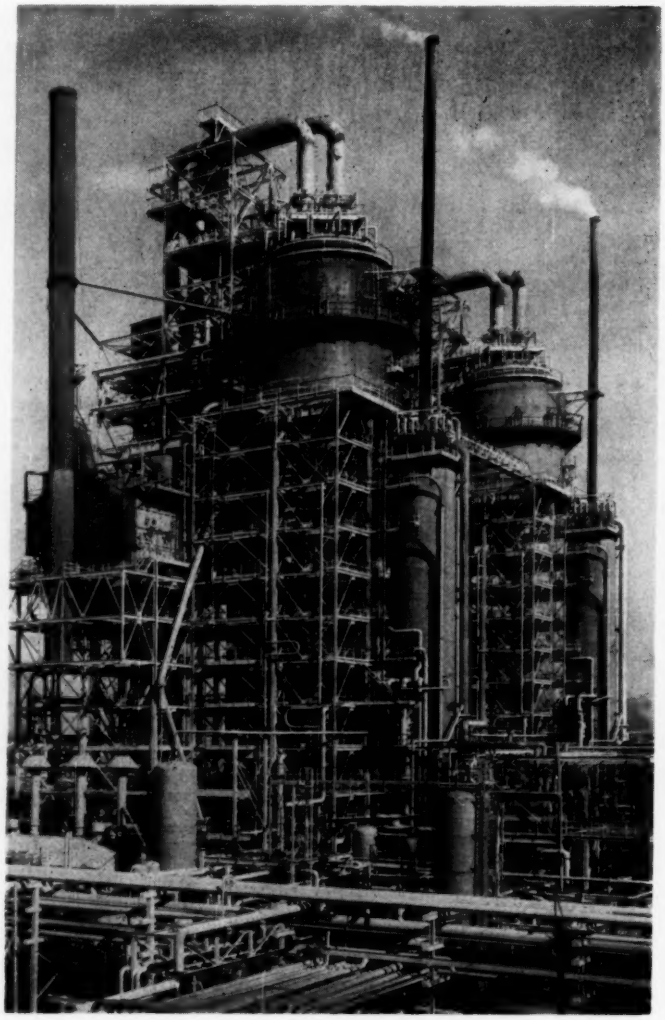

Cat Cracker Shatters World On-Stream Record

Fluid-bed catalytic cracking unit shown above, located at Esso Standard's Baton Rouge, La., refinery, became a world record holder last month, according to the company. By tenaciously staying in continuous operation for almost four solid years, the unit has won for itself the title of the hardiest, longest running "cat" around. Record run: 1,399 days of first-class service turning out high-octane gasoline without need for a single shutdown for inspection, maintenance or repairs. Previous long-run record was set about two years ago by a cat cracker at Cities Service's Lake Charles, La., refinery. It totaled up an uninterrupted run of 1,065 days. To push Esso's cat to the new record, notes company vice president H. J. Voorhies, required careful planning of operations and maintenance, and use of tougher materials of construction in the unit.

using more expensive naphtha feedstocks, yields are about 50%.

Electric-arc acetylene processes have never caught on in this country because the high investment and operating costs have never been entirely counterbalanced by the higher yields. The U. S.-developed Schoch process, for example, has been around for years but has never been able to find a commercial backer. Humble Oil Co. (Houston) currently has the rights to the Schoch process, but says it still has no commercial plans.

Because of its high yields, the new Czech process is claimed by its developers to be the cheapest route to acetylene—and specifically 15% cheaper than the d.c.-arc Huels process. Key to increased process efficiency is a saturated hydrocarbon quench, e.g., gasoline, which cracks into unsaturated compounds (mainly ethylene) on contacting the hot reacting gases.

Process was developed in a 650-2,000-v. furnace which employs special water-cooled, hollow copper electrodes spaced 1 mm. apart. Methane is injected into the electrodes tangentially, with flow rates varying from 175 to 355 scfh. Reaching the electric arc, expansion of the gas increases flow to over 10,000 cfh.

Do Dry Summers Lead To Sticky Politics?

If the coming summer should be as dry as the last one, the German Federal Republic (West Germany) may decide to make rain by seeding clouds with silver iodide. However, one consequence of this action could be trouble with eastern neighbors.

Estimates of such a seeding program give a cost of $1.2 million for 18 mo. of "milking." Rainfall could be increased by 10% in the northern German plains and by 20% in the southern hilly region where many water reservoirs are located.

But as nature—not politics—would have it, prevailing winds over Germany are easterly.

Processes & Technology continues on page 66.

SCOPE in INDUSTRY
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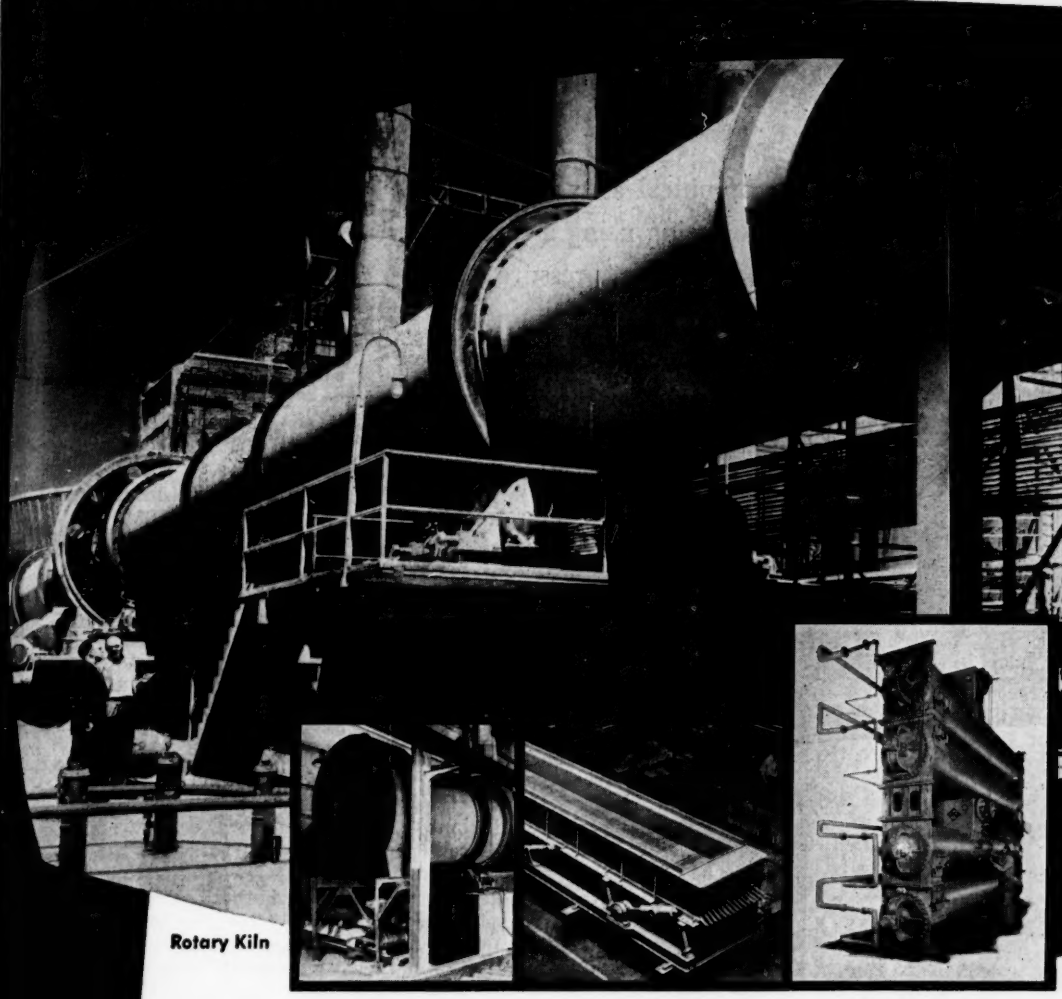

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Rotary Dryer

Air-Quenching Cooler

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Typical of the research and testing facilities which make this thorough analysis possible is the new A-C pilot plant which includes a complete *Grate-Kiln* system. Components, processes and techniques may be studied carefully under actual operating conditions. The results from these tests help A-C bring you the latest scientific advances in pyro-processing in each system you buy.

For more information, talk with your A-C representative. Or write for Bulletin 25C6177, to Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

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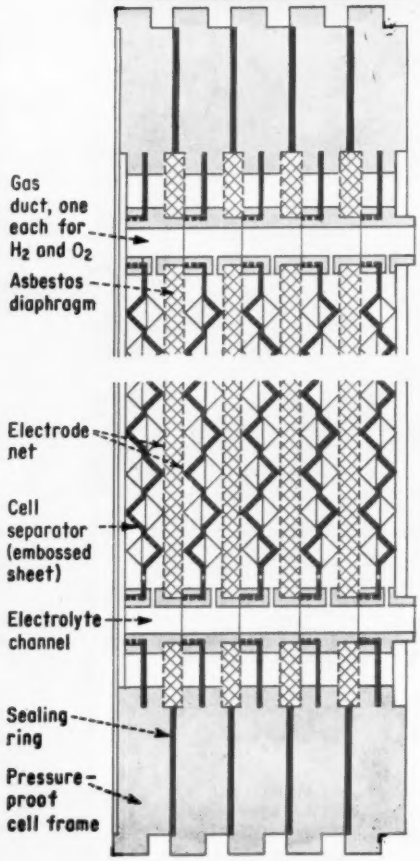
A-1190-C

Pressure Lowers Electrolytic H_2 Cost

Electrolysis is now more economical as a source of hydrogen for chemical processing using a recently developed cell that operates at 30 atm. pressure.



BIPOLAR design reduces size of Zdansky-Lonza pressure electrolyzer to cut H_2 cost.

As one of today's top chemical newsmakers, hydrogen now adds still another story to our columns.

This time it deserves story space because a new electrolysis plant scheduled to start up this spring at Waldshut/Rhine (near Loerrach) South Germany, will produce hydrogen cheaper than conventional electrolysis plants.

Reduction in cost results from use of a new-type pressure electrolyzer which operates at lower voltage level and, thus, consumes less power.

Electrolyzer was developed for Lonza AG, Basel, Switzerland, by A. E. Zdansky. Lonza will operate the new German plant which was built by Lurgi-Gesellschaft fuer Waermetechnik, Frankfurt am Main, general sales licensee for Zdansky-Lonza electrolysis plants.

▶ **One of Five**—The installation at Waldshut/Rhine is the fifth since Lonza first started up a full-size unit in its Ackersand nitrogen works early in 1955. It will incorporate recent improvements added by Lurgi.

Previous installations include two at Ackersand, one at Montey, Switzerland, operated by the Djevahirdijan firm and one at Hamburg operated by Noblee & Thoerl.

▶ **What Pressure Saves** — All these plants use electrolyzers containing bipolar cells which are one-fifth the size of conventional monopolar cells and which produce hydrogen at 30 atm.

By operating at 30 atm., these electrolyzers can:

- Use lower voltage; voltage decreases as pressure rises.
- Carry higher amperage, reducing cell voltage still further, because they can tolerate 212 F., or higher, temperature.
- Operate with specific power consumption of 0.123-0.128 kwh./scf. H_2, down from 0.145-kwh./scf. level of atmospheric-pressure electrolyzers.
- Utilize energy more efficiently, up from 65 to 85%.
- Use 50% less cooling water.
- Decrease maintenance costs.
- Save some mechanical compression costs by delivering gas at 30 atm. pressure.

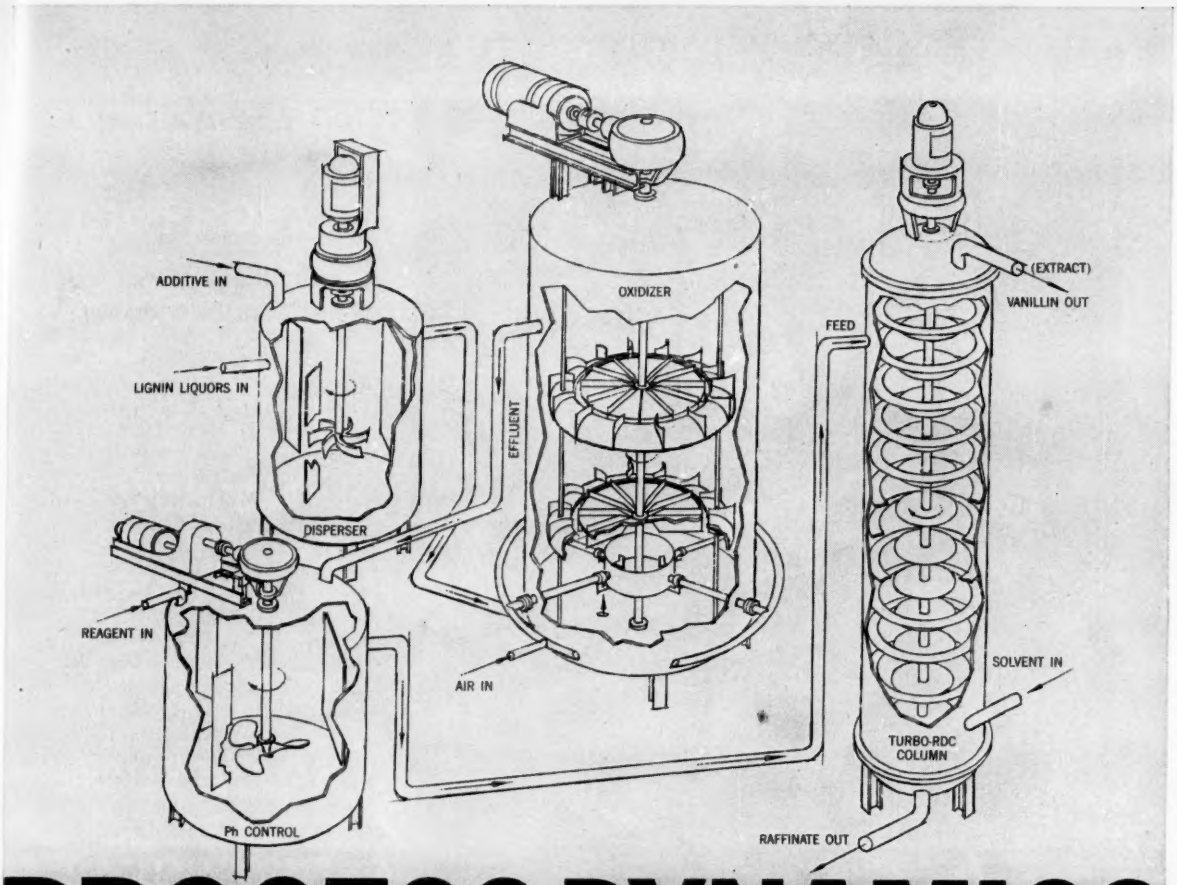
▶ **Biggest Yet**—While the previous four plants operate at 2,000-4,000 amp., the new plant at Waldshut/Rhine will run its electrolyzers at 3,000-6,000 amp.

This improved version, developed by Lurgi, offers the advantage of fewer cells than the units in the other four plants. To produce 14,350 scf./hr. H_2, a 4,000-amp. electrolyzer would need 500 cells. Lurgi's 6,000-amp. unit can reach this output with only 340 cells. While slightly wider, the 6,000-amp. cells consume only 0.1 kwh. more power per standard cubic foot of hydrogen.

▶ **Bipolar Cell**—Each of the narrow, bipolar pressure cells in a Zdansky electrolyzer is enclosed by waffled plates inserted in a ring-shaped pressure frame. These plates support nickel-plated wire gauze, one serving as the cathode and the other as the anode.

In the space between anode and cathode gauze are diaphragms of pure asbestos, 3 mm. thick. And the pressure frames supporting each cell assembly are separated by Teflon-covered packing.

▶ **Assembled in Packs** — Cells, which are only 12-mm. thick, are connected in series to form portable packs containing 100-125.



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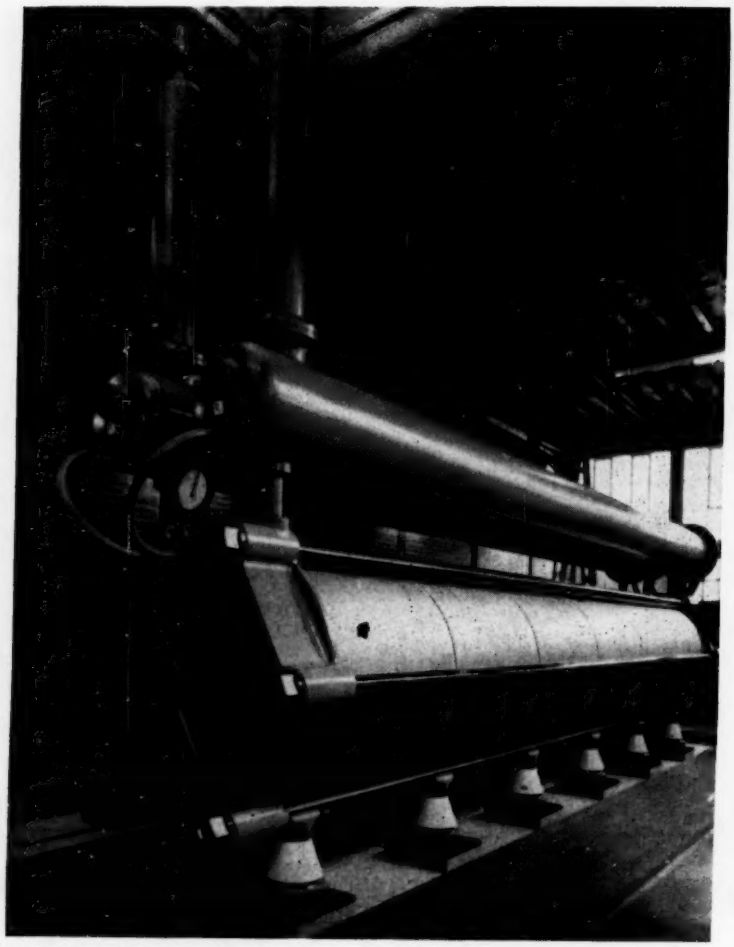

COMPACT Zdansky-Lonza hydrogen producer contains 660 bipolar cells.

Several of these packs are then assembled between two strong end plates pulled together by six tie rods.

In assembled form, the cells have two gas ducts on top for hydrogen and oxygen and one duct below for electrolyte. The gas ducts feed overhead into two high-pressure tanks where the gases separate from the electrolyte.

► **Cool and Recycle**—Each separator tank contains cooling coils to reduce electrolyte temperature before it returns to the cells via the lower electrolyte channel.

At one end of each tank is a short column down which feeds high purity makeup water, cooling and washing upflowing gas moving to discharge valves.

► **Easy to Operate** — Operation of the Zdansky-Lonza electrolyzer is essentially automatic. Operators only check temperatures, pressures and cell voltages periodically. If gas pressure exceeds 35 atm., electric power cuts off automatically. And other safety devices protect against a gas leak.

Startup takes place under nitrogen while the caustic potash is circulating for heating. Unit reaches normal operating temperature within few minutes.

Direct current enters through busbars at the center of the unit and leaves via grounded shunts at each end. Half the entering current feeds toward one end and the other half toward the other end.

With consumption of this power reduced by the pressure design, Lurgi hopes to win new advocates for electrolytic hydrogen.

Larger Plastic Articles Made With New Process

Spencer Chemical Co. is introducing a new thermoplastic fabrication process into this country which is claimed to virtually eliminate the size limitations imposed on molded plastic objects by older fabricating methods. Called the Engel Process, technique was developed by the Vaessen-Schoemaker Co. of Holland and will be licensed by Spencer to fabricators in this country.

Process involves fusing of a powdered thermoplastic (especially polyethylene) in an oven and can be adapted to forming hollow articles of almost unlimited size in a relatively inexpensive mold. As an example of what can be done with the process, Spencer says that 10-ft. polyethylene pleasure boats and 500-gal. tanks are already being produced in Europe.

To promote the new process, Spencer has a pilot plant under construction in Orange, Tex., which will develop improved grades of the special powdered polyethylene required by the new method. Removal of the size limitation, Spencer believes, will open up many new outlets for polyethylene for such uses as large (13-15 gal.) multitrip carboys, drum liners, large boxes and molded furniture.

Another Step Taken to Cut Water Evaporation

A new device for spreading cetyl alcohol on water promises to lower costs of preventing water loss from large reservoirs or storage tanks. A fine dust of cetyl alcohol is blown over water, eventually forms a monomolecular film on the surface to curb evaporation losses.

The new device has been tested in Australia, where earlier work

ETHYL ALCOHOL

ISOPROPYL ALCOHOL

SECONDARY BUTYL ALCOHOL

ACETONE

METHYL ETHYL KETONE

ETHYL ACETATE

ISOPROPYL ACETATE

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with cetyl alcohol ($C_{16}H_{33}OH$) was done. New method uses a specially developed machine mounted on a boat. A coarse wire brush, rotating at high speed, shreds solid cetyl alcohol to a fine powder, which is then blown by a fan onto the water through a delivery tube. Operating costs are small and water losses can be cut possibly by 50%.

Considerable work has been done in the U. S. with cetyl alcohol, some by the U. S. Bureau of Reclamation near Oklahoma City (*Chem. Eng.*, June 1957, p. 158). Bureau found that losses were cut by 45-65%, with little or no effect on odor and taste or on fish and organic life. Other work has been done in Texas with aqueous suspensions of octadecanol and hexadecanol (*Chem. Eng.*, Aug. 11, 1958, p. 82).

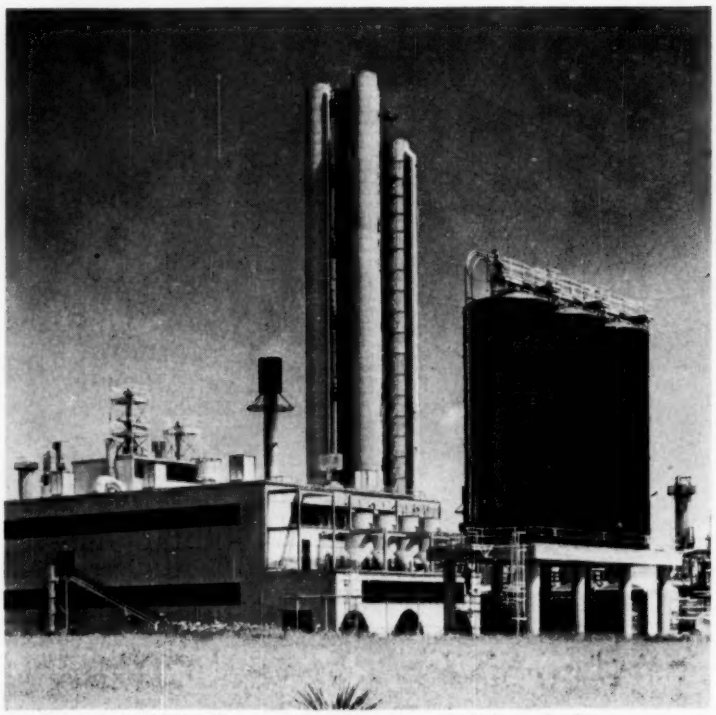
Shell Joins Transoceanic Liquid Methane Shippers

Royal Dutch Shell Group, through its Canadian Shell Ltd. affiliate, has bought into the successful venture of shipping liquid methane across the Atlantic Ocean (*Chementator*, Apr. 6, 1959, p. 72).

Shell has acquired 40% interest in the Constock International Methane Corp., which, jointly with the British Gas Council, is in the business of shipping 2,000-ton cargoes of liquid methane aboard its unique ocean-going vessel, *Methane Pioneer*, from Lake Charles, La., to Canvey Island in the mouth of the River Thames, England. Continental Oil owns 40% and Union Stockyards 20% of the firm. First result of Shell's addition as a major stockholder: a name change. Henceforth Constock will be known as Conch International Methane Ltd.

Methane Pioneer completed its maiden transoceanic voyage just about one year ago. Since that time the vessel has completed five more journeys carrying, each time, 2,000 tons (32,000 bbl.) of liquid methane for the London metropolitan "town gas" market.

INDUSTRY NEWS



STYRENE MONOMER capacity soon to be tripled at Cosden.

Cosden Petroleum Corp. plans construction of new capacity at its Big Spring, Tex., plant to triple present 10,000-ton/yr. styrene monomer capacity. Cosden has contracted Badger Manufacturing Co. for design, engineering and construction of the expansion. Included in the planned plant is a Universal Oil Products Alkar unit for ethylbenzene catalytic alkylation of benzene with ethylene. Next process step completes the route from benzene to styrene.

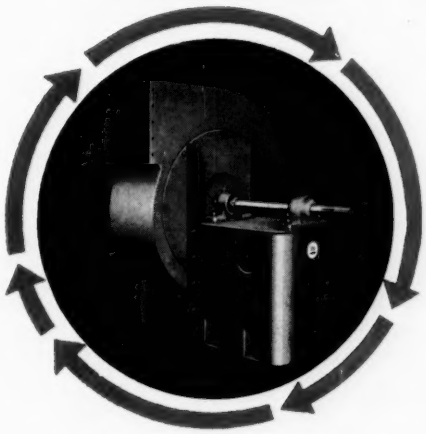
Hooker Chemical Corp. announces plans for construction of a $10-million expansion of its Niagara Falls, N. Y., caustic-chlorine plant. Hooker plans to add 120,000-amp. Hoechst-Uhde mercury cells to its present diaphragm-cell plant.

Dow Chemical Co. is continuing its major expansion of polyethylene capacity in Texas. Engineering has begun of a 67% capacity increase at Freeport, Tex., to be completed in 1961. Two other polyethylene plants at Plaquemine, La., and Bay City, Mich., will soon go on stream.

Texas Gulf Sulfur Co. discloses plans for construction of a $1-million sulfur-filtration plant at its Spindletop mine near Beaumont, Tex. Texas Gulf has contracted Consolidated Western Steel Div. of United States Steel Corp. to construct the new plant.

Olin Mathieson Chemical Corp. announces construction of an ethylene oxide plant at its Doe Run works near Brandenburg, Ky. Plant is part of a $30-mil-

Industry News continues on page 170.



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Chemical capital dollars yield

more instrument dollars when . . .

. . . modernizing or expanding.

. . . new plant is big or ***small.***

. . . process is ***wet*** *or dry, batch or* ***continuous.***

. . . business is going up or ***down.***

Better Forecasts of Instrument Sales

Capital spending plans herald sales of instruments—and any other chemical process hardware. But one man's dollar may buy more than another's.

None of the display statements above (in color) are particularly profound by themselves. Taken collectively, though, they serve to help us understand how a capital dollar spent in one place, for one purpose, can be worth—in terms of instrument sales—three, four, or even more, dollars spent someplace else.

Louis Edelman, analyst in the Scientific, Motion Picture and Photographic Products Div., U. S. Dept. of Commerce, appreciates this dollar distinction and makes good use of it in forcasting instrument sales.*

Although most of Edelman's present work is in the instrumentation field, his philosophy is well worth application to the sales forecasting of any of the classes of chemical process hardware.

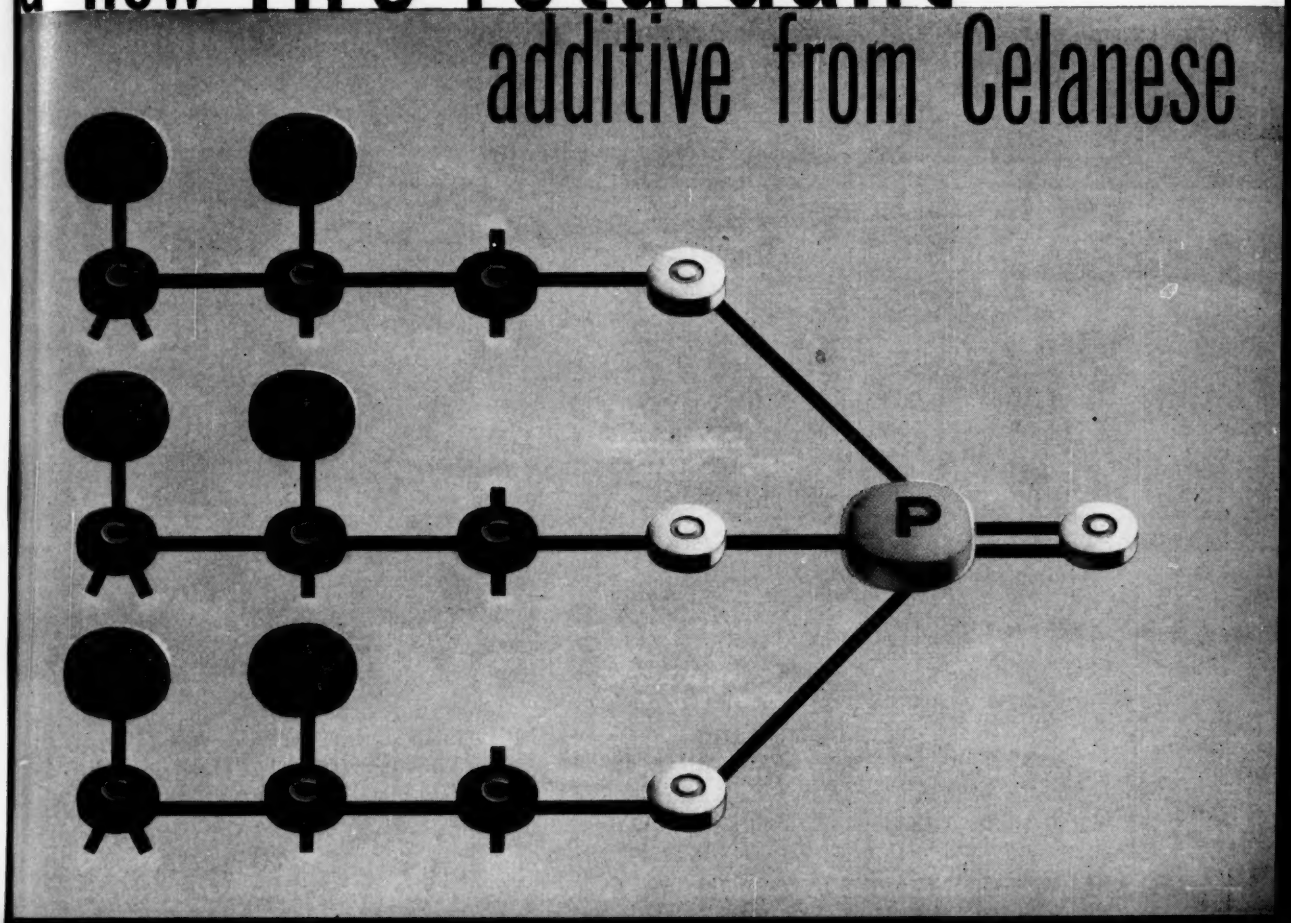
▶ **Dollars Are Different**—Variation among capital dollars and their instrument buying power is most pronounced when comparing different industries. For example, says Edelman, the chemical industry's capital dollar buys, on the average, three times as much instrumentation as the petroleum industry's dollar, five times as much as the public utilities' dollar, three times as much as all other manufacturing, and fifty times as much as all other nonmanufacturing (see table, next page).

Putting it another way, instrument costs may run as high as 15% of total chemical plant costs, whereas similar expenditures for paper and pulp, iron and steel, rubber products and electric power stations are not likely to exceed 3% of total plant costs, according to Edelman's data. (Petroleum instrumentation may run to 12% of total plant costs.)

Instrumentation's share of costs may vary significantly within an industry—as indicated by the conditions of modernization vs. expansion, big vs. small plants, etc., listed above for the chemical industry. Within the petroleum industry, the instrumentation portion of total plant costs depends on whether the money is being spent on refining

*Edelman is one of those too-few economists who does not appear to believe that the future of any segment of the economy can be confidently predicted either by extrapolation of an historical trend line or by correlation with numerous time-series relationships ranging from the GNP to the movement of polar ice caps on Mars. He says "Due to the very nature of the economic system, with its web of interdependence between all economic variables, it is always possible to find a statistical correlation between two economic time series, no matter how remotely related they may be."

a new fire-retardant additive from Celanese



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Chemical Dollars Buy More Instruments

Industry	% of Industrial Capital Outlay	% of Industrial Outlay For Instruments*
Chemical	4	22
Petroleum	10	16
Public utilities	15	17
All other mfg.	24	40
All other nonmfg.	47	5

* About 75% of all instrument sales result from capital spending by industry (average for 1947-57). Remaining sales are attributable to research, development and other scientific outlays, to component instrument buying (for incorporation in end products or systems), or are unaccounted for (6%).

facilities alone, or includes such "grass roots" installations as storage tanks and auxiliary power stations.

▶ **Looking Behind** — Edelman uses historical data, but only sparingly. For those who like this approach, Edelman has plotted instrument sales since 1946, from which he has derived the following equation:

$$\frac{s}{s_0} = e^{kt}$$

where s_o = total instrument sales in all industries in a base year, s = sales in a given year, t = the number of years from base year to given year and k (the growth constant) = 0.1089.

▶ **Looking Ahead** — He prefers to forecast on the basis of anticipatory data: capital expenditures for plant and equipment, budgeted military spending for aircraft and missiles, budgeted government spending for additions to research and development plant. Within each data category, Edelman attempts as much refinement as available data will permit.

In the area of capital spending, he first regards each industry by itself, since in any particular plant use of instruments is guided by two considerations: amenability of the process to instrumentation and degree to which management is convinced that instrumentation is a paying proposition. Some idea is needed of the ratio of cost of instrumentation in a plant and total cost of the plant—for various industries.

▶ **Weighted Dollars** — Edelman performed a partial correlation analysis on sales figures collected since 1945 in order to weight proportionately each industry's capital dollar in terms of its instrument buying power (see table above).

Another industry variable: distribution between cost of the plant and the cost of the equipment. The ratio of bricks to hardware can vary, according to the business situation, from 30-70 during a business turndown, to 70-30 during a business upswing, says Edelman.

The greater the proportion going toward modernization of existing facilities — relatively high in a recession—rather than plant expansion, the larger the share of capital funds allocated to instrumentation.

Project size is a controlling factor, too. According to Dow Chemical data, instrument cost for continuous processes may vary, as a percent of total direct project cost, from 8-11% for a $1-million project, to 5-7% for an $8-million job. Instrument costs under the same conditions may vary, as percent of purchased process equipment cost, from 35-45% to 10-20% (*Chem. Eng.*, Jan. 25, 1960, p. 120).

▶ **R&D Spending**—Edelman has words of caution concerning spending for research and development instrumentation. Although it's common practice to relate sales to total expenditures in this area, the forecaster must remember that R&D spending includes salaries of personnel, supplies and overhead, and other like items.

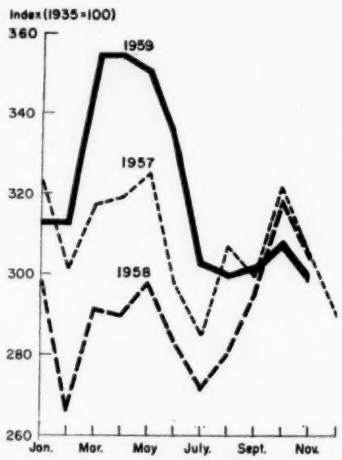
"It is possible for research and development outlays to increase substantially, without one additional laboratory instrument being sold, by adding more research workers to the staff, buying more supplies and using available instruments more intensively."

Analysis of spending patterns of government spending for R&D reveals some interesting inconsistencies.* Spending for increases in research and development facilities ranged from 9% to 18% of total spending increases for R&D between 1948 and 1958.

Thus, cost of conducting R&D may rise while spending for new facilities—and new instrumentation—is declining, as was the case in 1951-55.

*Government budgetary information provides the only data in which research and development expenditures are divided into those funds for conducting R&D and those funds for additional facilities.

Chemical Consumption



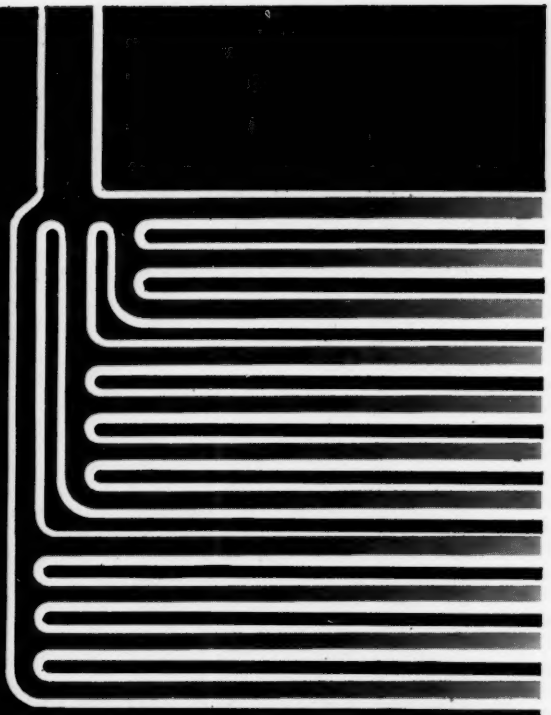
Consumption by Industries

	Oct. (Final)	Nov. (Est.)
Coal products	2.2	7.1
Explosives	10.6	9.1
Fertilizer	72.9	73.7
Glass	29.5	26.1
Iron & Steel	3.1	1.3
Leather	4.3	4.4
Paints & Varnish	34.4	29.2
Petroleum refining	30.9	30.9
Plastics	32.3	34.7
Pulp & Paper	43.7	41.0
Rayon	25.8	24.6
Rubber	8.1	6.8
Textiles	10.6	10.5
Total	**308**	**299**

MULTI-ZONE

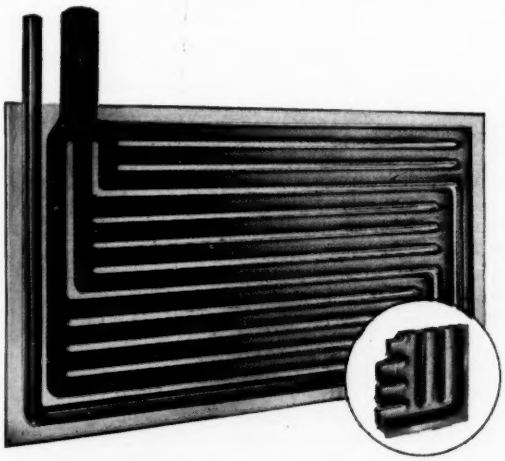
PLATECOIL®

IS AN EXCLUSIVE TRANTER ADVANCEMENT IN HEAT TRANSFER TECHNOLOGY



The new MULTI-ZONE PLATECOIL introduces a new principle of coil design. The multiple header, multiple return pass arrangement produces FREE-FLO action. Steam is distributed to all levels of the coil almost instantaneously. This new design overcomes the problem of condensate "trapping" — a disadvantage of common pipe coils and single-headered units—that robs effective heat transfer area. Only TRANTER PLATECOIL offers the extra capacity of MULTI-ZONE heat distribution.

MULTI-ZONE PERFORMANCE SOLVES TOUGH TANK AND PROCESS HEATING PROBLEMS



Better steam distribution provides a reserve capacity for heat transfer to overcome overload conditions which drop tank and process vessel temperatures. Heat-up time after tank or processing equipment shut-down is cut to a minimum. Tank temperatures are maintained within closer limits and production is improved.

More effective heat transfer area and more heat transfer per square foot of area makes it possible to use fewer and more compact PLATECOIL units than is possible with other types of equipment. Valuable tank space is saved and the need for addition of new tanks to get higher production is often eliminated.

Add to these performance advantages, low cost of installation and operation, economical maintenance and scientific engineering for the best answer to your heat transfer problems.

Write for NEW Bulletin P61 for complete data.

Tranter Manufacturing, Inc.

LANSING 9, MICHIGAN

PLATECOIL® DIVISION

FLEX STRENGTHS of new epoxy systems excel due to resins' unsaturation.

New Epoxies Cut Process Costs

New resins are more reactive, offer more scope in low cost curing agents, are less dense and go further.

Food Machinery & Chemical has entered the field with a new family of epoxy resins called Oxiron resins. They are different from conventional epoxies and from other commercial epoxy variations (*Chem. Eng.*, Feb. 22, 1960, p. 56). They are epoxidized polyolefins, not condensation products of polyhydric phenols, such as bisphenol and epichlorohydrin epoxies.

Each of the Oxiron resins is liquid at room temperatures, but differs in viscosity. Oxiron 2000 is a high-viscosity resin recommended primarily for laminating and adhesive applications. Oxiron 2001 is a low-viscosity version of 2000. It is recommended for casting and encapsulation as well as laminating and adhesive use. Oxiron 2002 displays still lower viscosity. It is recommended for laminating and casting applications. The 2002 resin possesses enhanced double bond reactivity compared with 2000 and 2001.

The products can react in a number of ways and with a variety of curing agents. This polyfunctional behavior is a result of molecular structure. The molecule has reactive sites located at many points along the aliphatic hydrocarbon chain that forms its backbone.

Epoxy groups are located both at external positions and internally along the hydrocarbon backbone. This arrangement contrasts with conventional epoxy structure in which there are only two terminal epoxy groups in the resin molecule.

In addition to the numerous epoxy groups, there are other reaction sites. Hydroxyl groups along the hydrocarbon chain provide initial reactivity, and in some types of cures, there is a certain amount of epoxy-hydroxyl group interaction. The resins possess vinyl functionality and consequently can be cured with the usual peroxide catalysts, such as dicumyl peroxide. The cured product displays low mechanical distortion at elevated temperatures and high flexural strength.

As contrasted with conventional epoxy resins, they react readily with anhydrides and dibasic acids at low temperatures to give hard materials with good heat distortion performance. Room-temperature curing systems are possible and are currently under development.

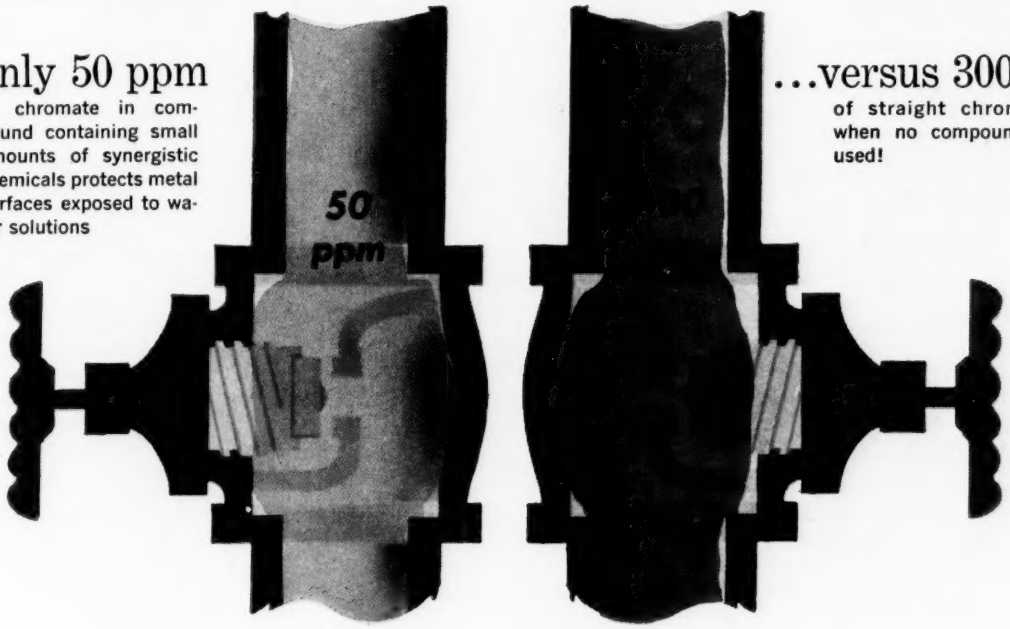
The resins display very little room-temperature reactivity when mixed with polyamines. However, such mixtures do react readily at moderately elevated temperatures—in the range of 100 to 150 C. Amine systems are especially attractive where long pot life is a requirement as it often is in lay-up work for laminating.

Many of the curing agents that can be used effectively with Oxiron epoxy resins, such as anhydrides, acids and glycols, are relatively low-cost materials. They are used in fairly high proportions with the resin. Also, the systems yield products with superior strength-to-weight ratios. The uncured resin is about 20% lighter than conventional epoxy resins. This feature is noteworthy in structural and electrical applications where weight considerations are important.

The resins also show superior high-temperature performance. After long exposure to heat,

Cut costs of corrosion control with compounds based on Mutual Chromates

Only 50 ppm
of chromate in compound containing small amounts of synergistic chemicals protects metal surfaces exposed to water solutions



...versus 300 ppm
of straight chromate when no compound is used!

In a typical open recirculating water system such as a cooling tower, you can save many dollars each year by using a chromate *compound* instead of chromate alone to avoid pitting! Corrosion can be kept to 3 mils per year penetration or less! The compound's *blend* of ingredients produces a synergistic effect . . . results are *better* than the sum of the effects of the individual components used separately. Comparable savings can also be realized with chromate compounds in compressors, stationary diesel engines, marine and locomotive diesel engines, mercury arc rectifiers and ammonia condensers.

Easy-to-use chromate compounds make waters non-corrosive while making metal surfaces corrosion-resistant. To keep new recirculating water systems corrosion-free, add them before operation begins. Applied to older systems, they arrest rust and scale. You can choose from several types of compounds to find the one that best meets your particular condition and equipment.

Mail coupon for the names of leading manufacturers of corrosion inhibiting compounds containing Mutual Chromates and information on Mutual chromium chemicals.

MUTUAL® CHROMIUM CHEMICALS

Sodium Bichromate	Potassium Bichromate
Sodium Chromate	Potassium Chromate
Chromic Acid	Ammonium Bichromate

Koreon (one-bath chrome tan)

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MUTUAL chromium chemicals are available through dealers and SOLVAY branch offices located in major centers from coast to coast. Send export inquiries to Allied Chemical International, 40 Rector St., N. Y. 6.

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cured resins display low weight loss, and they retain such physical properties as flexural strength very well.

Electrical properties of cured epoxies in this family are good—essentially comparable to epoxies of the glycidyl ether type.—**Food Machinery & Chemical Co., New York.** **76A**

Emulsifiers

Nonionic products promise use in agricultural sprays, plasticizers.

A new series of nonionic emulsifiers with bland odor, pale color and excellent heat stability has been developed. Marketed under the name Peglo, these materials are esters of selected tall oil acids.

The manufacturer reports that almost any emulsification problem can be handled, working with only three grades of the material. By blending two numerically successive Peglos, a complete range of emulsifiers can be obtained.

	Peglo 9	Peglo 12	Peglo 15
Color, NPA, max.	2	2	2
Lb./gal.	8.40	8.15	7.95
Neut. No., max.	5	5	5
Sap. No.	85/95	115/125	145/155
Iodine No.	55/65	75/85	85/95
Pour pt., approx.	70	5	20
Flash pt., approx.	515	530	485
Viscosity, SSU @ 100 F.	240/270	160/190	130/150

Being nonionic, the Peglos may be used to complement either cationic or anionic surfactants without adversely affecting desired properties of either compound. Fast-dispersing kerosenes, self-emulsifying insecticide formulations and water-in-oil emulsions are representative applications.

Also, according to the manufacturer, they are used for the new emulsifiers in agricultural sprays, automobile cleaners, plasticizers and floor polishes. In the metal working industry Peglos may be used for emulsifying metal cleaners, soluble cutting oils, mold lubricants and drawing compounds. There are other known applications in textile, rubber, leather and dry cleaning industries. Products have not been tested for cosmetic or food use.—**Pennsylvania Refining, Butler, Pa.** **78A**

Tungsten Coatings

Simple & complex shapes can now be plated with 2,000-C.-resistant W.

High-purity tungsten can now be easily plated on metal surfaces by using a vapor deposition process which the National Bureau of Standards has developed for the Navy. The method involves reducing gaseous tungsten hexafluoride with hydrogen by passing it over the heated object to be plated. At temperatures above 300 C., tungsten is deposited on the hot surface, and the only other reaction product, hydrogen fluoride, passes out with the excess of hydrogen.

By this method, it is possible to coat numerous simple and complex surfaces such as rocket and missile nozzles and jet engine parts. The technique also lends itself to the fabrication of tungsten articles, and may be the only way that complicated shapes of tungsten are able to be formed. Simple tungsten shapes for application in vacuum tubes have already been fabricated.

Tungsten is one of the few metals that possess structural strength at temperatures above 2,000 C. Its extremely high melting point, 3,140 C., hardness, and corrosion resistance make it a desirable material for high-temperature equipment. However, until lately, the high-temperature properties could not be effectively utilized. Its brittleness and hardness prevented it from being machined by conventional methods while weight of the tungsten restricted its applications in aeronautical equipment.

Because tungsten deposition has not been accomplished from either aqueous or organic solutions, it was necessary to evaluate deposition from both fused electrolytes and the gaseous phase. However, in the fused electrolyte processes, the rate of plating was too slow, the deposit was too rough, and coatings could not be built up to the desired thickness. — **National Bureau of Standards, Washington 25, D. C.** **78B**

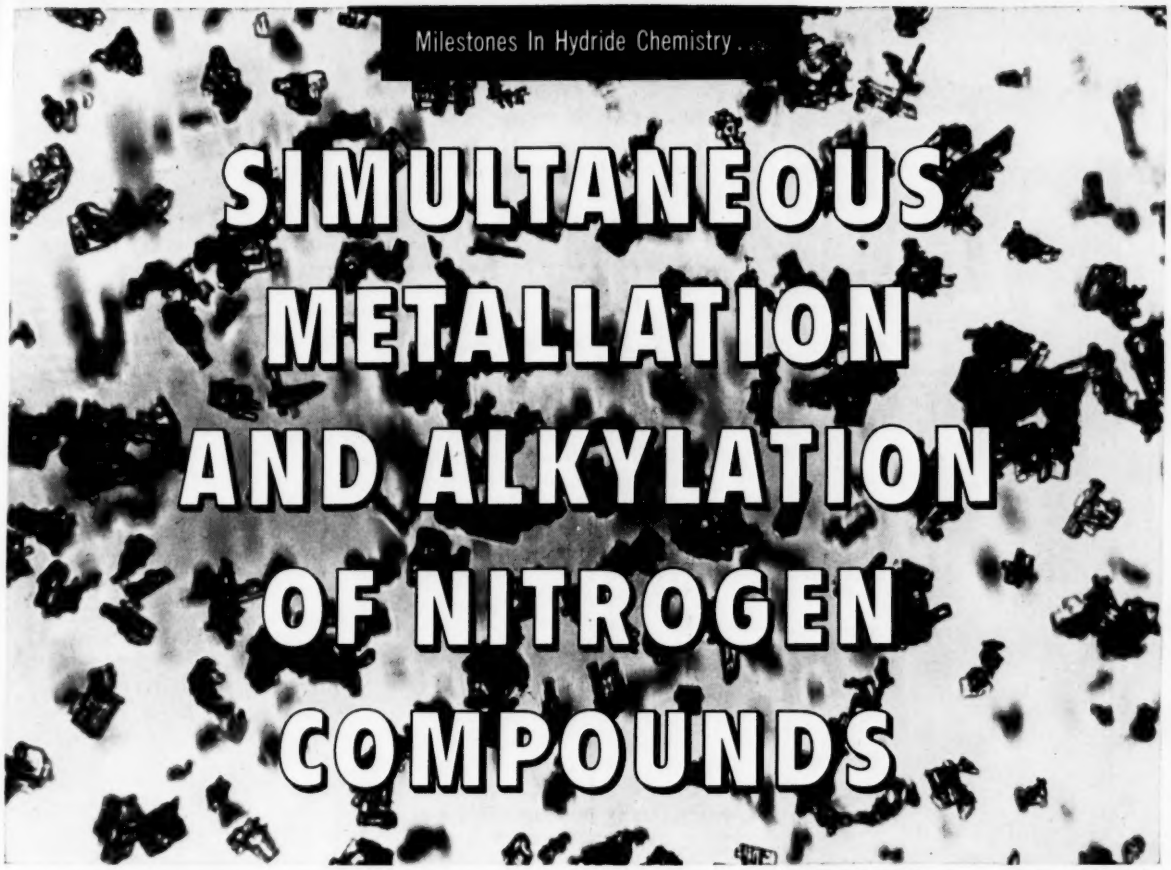
Chemicals continues on page 80.

Newsworthy Chemicals

Page Number is also Reader Service Code Number

New epoxies cut process costs..... **76A**
Nonionic emulsifiers improve agricultural sprays..... **78A**
Tungsten coatings are now easier to apply..... **78B**
Silicone-glycol aids cell structure of plastic foam..... **80A**
Epoxy resin excels in high temperature service..... **80B**
Adhesive stops slippage of palleted polyethylene bags... **80C**
Herbicide safe for post-emergence use on tomatoes..... **80D**
Tantalum powder, capacitor grade, reduced in price..... **80E**
Polyethylene now reprocessed in dense, pellet form..... **80F**

For more details, use Reader Service Card



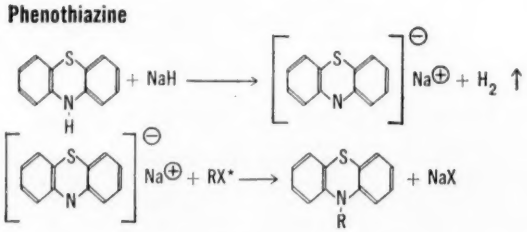
160X Photomicrograph of sodium hydride oil dispersion

With MHI Sodium Hydride Oil Dispersion

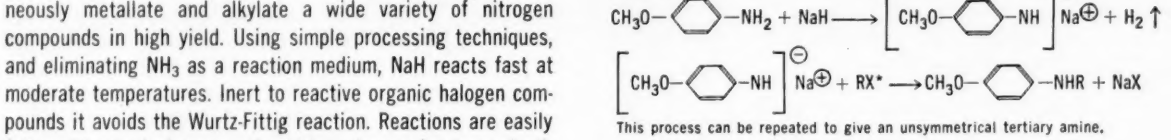
In a single step, in many cases, MHI NaH in oil will simultaneously metallate and alkylate a wide variety of nitrogen compounds in high yield. Using simple processing techniques, and eliminating NH_3 as a reaction medium, NaH reacts fast at moderate temperatures. Inert to reactive organic halogen compounds it avoids the Wurtz-Fittig reaction. Reactions are easily followed by the hydrogen evolved (the only reaction by-product).

Using diglyme (dimethyl ether of diethylene glycol), dimethyl formamide, or mixtures of these with hydrocarbons as solvents, here are selected examples:

Phenothiazine

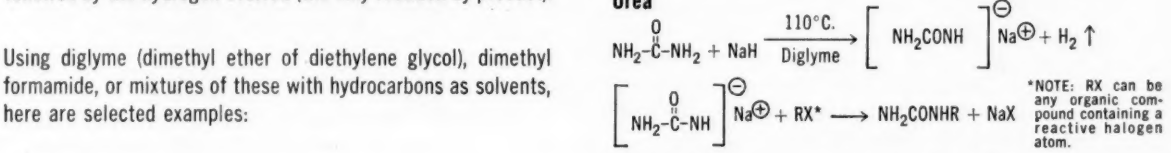


p-Anisidine



This process can be repeated to give an unsymmetrical tertiary amine.

Urea



*NOTE: RX can be any organic compound containing a reactive halogen atom.

MHI NaH oil dispersion is available in quantity as a stable 50% mealy dispersion of 5-20 micron crystals in mineral oil. The oil coating protects reactivity, even in air, making it easy and safe to handle.

Write for your copy of the 20-page brochure, "Sodium Hydride Dispersed In Oil," a manual covering properties, reactions, handling and safety.

CHEMICAL HYDRIDE DIVISION

Metal Hydrides Incorporated

PIONEERS IN HYDRIDE CHEMISTRY

37 W. CONGRESS STREET, BEVERLY, MASSACHUSETTS

TREATED

UNTREATED

Silicone-Glycol

Provides firm cell structure in preparation of low-density urethane foam.

A new silicone-glycol copolymer, developed especially for the one-shot polyurethane process, facilitates production, yields fine cell structure and helps produce low density foam.

Called Dow Corning 199, it is now commercially available. It offers such advantages as low foam density, low cost, ease of addition, firm foam structure during rise period, speed of processing foam.

Typical one-shot flexible foam formulations list use of 0.5% or less. Also effective in the production of rigid polyether foams, product is generally used in such materials at concentrations in the range of 0.3%.

In rigid foams, it promotes the formation of small, uniform cells, produces a high percentage of closed cells. This effect is the reverse of its behavior in one-shot flexible foams, where it gives a high concentration of open cells.—**Dow Corning Corp., Midland, Mich.** 80A

Epoxy Resin

Gives better high temperature service than conventional epoxies.

A new epoxy novolac resin appears to combine the useful physical and handling properties of conventional epoxies with the high temperature performance of phenolic resins. The new resin, D.E.N. 438, has been field tested in laminating, casting and adhesive applications for two years.

Systems that function well at temperatures above 400 F. are formulated with D.E.N. and common epoxy curing agents. The epoxy novolac holds promise in all applications where conventional epoxies are now being used, but where higher temperature service is desirable.

The range of applications include adhesives, structural laminates, prepreg laminates, filament-wound structures, tools, castings, printed circuit board and electrical insulation. Coating applications are also being investigated.

Formerly called Experimental Resin X-2638.3, the new product is now in large scale production and is priced at 68¢/lb. in truckload quantities. Solutions in acetone and methyl ethyl ketone are available.—**Dow Chemical Co., Midland, Mich.** 80B

Adhesive

Prevents slipping of palletized polyethylene bags.

A new water-soluble polymeric adhesive, designated PM-22, is said to resist horizontal shear and, therefore, to permit easy vertical separation of the stacked polyethylene shipping bags.

Because it is water soluble, the new adhesive can be removed easily and does not damage printing or stenciling. The absence of organic solvents eliminates toxicity and fire hazards.

The new material, priced at $57.50/hundred pounds in lots of four 55-gal. drums, is based on a carboxyl containing copolymer.—**Monsanto Chemical Co., Springfield, Mass.** 80C

Briefs

Foliar spray, based on newly developed herbicide (N-(3-chloro-4-methyl-phenyl) 2-methylpentanamide, has been tested and found to offer effective weed control in transplanted tomatoes. Available herbicides have been limited to use prior to the emergence of weeds due to their toxic effects on plants. Called Solan, the new spray is believed to be the first both safe and effective post emergent spray.—**Food Machinery & Chemical Corp., Middleport, N. Y.** 80D

Tantalum powder of capacitor grade has been reduced in price for the first time in five years by Kawecki. Company's Lo-Cap and Hi-Cap products are affected. Formerly $58.60/lb., tantalum powder now is available for $49.80/lb. in minimum 200-lb. shipments.—**Kawecki Chemical Co., Boyertown, Pa.** 80E

Reprocessed polyethylene film in dense, pellet form is now available. Pelleted product is said to represent a 20% savings in raw material cost in comparison with fused type pellets currently in use.—**Interplastics Corp., N. Y.** 80F

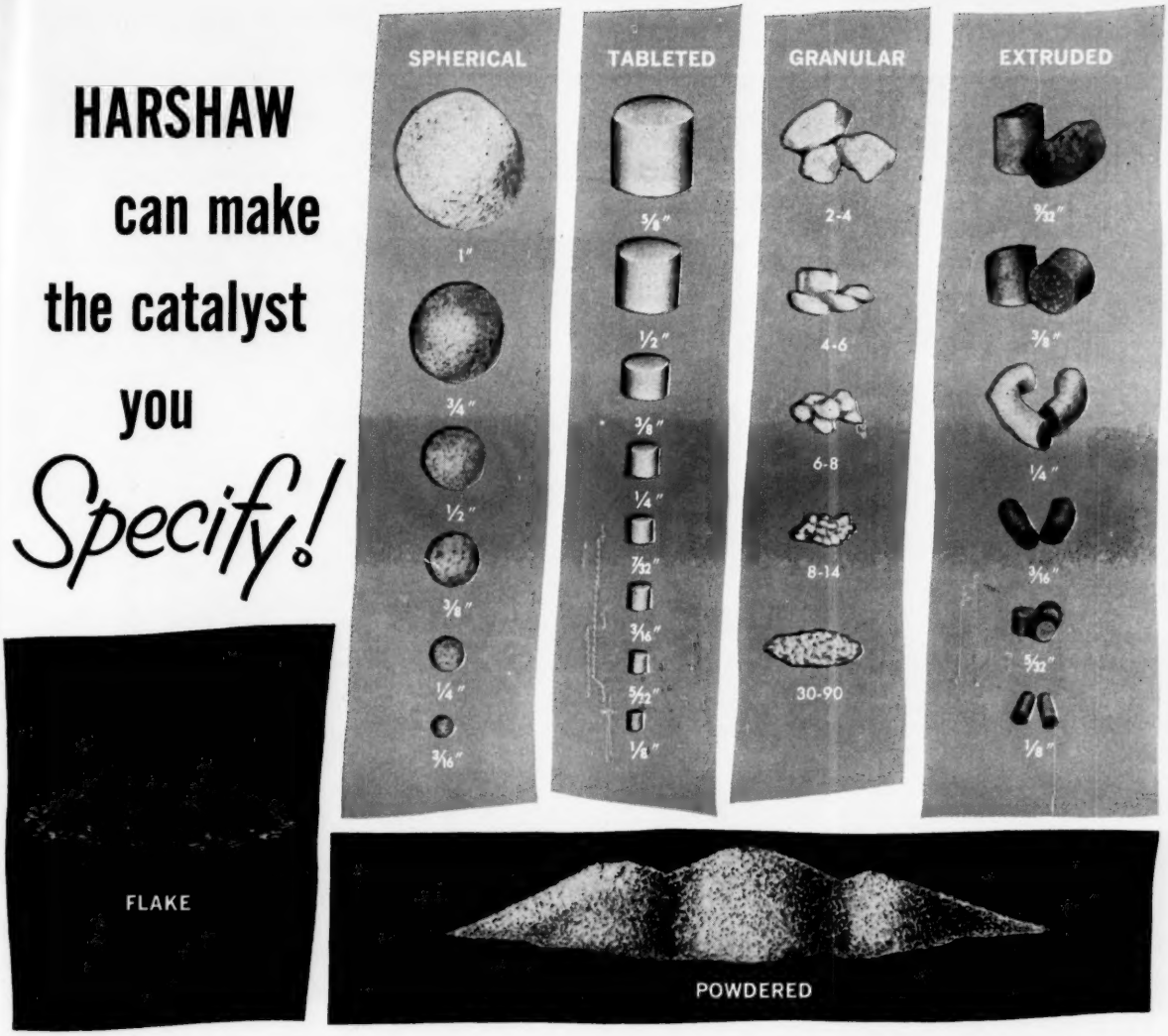
For More Information

about any item in this department, circle its code number on the

Reader Service

postcard (p. 207)

HARSHAW can make the catalyst you *Specify!*



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Aluminum Nitrate		Cobalt Nitrate
Copper Nitrate		Manganese Nitrate Solution
Metallic Soaps (Cobalt, Manganese)		
Nickel Carbonate	Nickel Formate	Nickel Nitrate
Nickel Sulfate	Sodium Methoxide	Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

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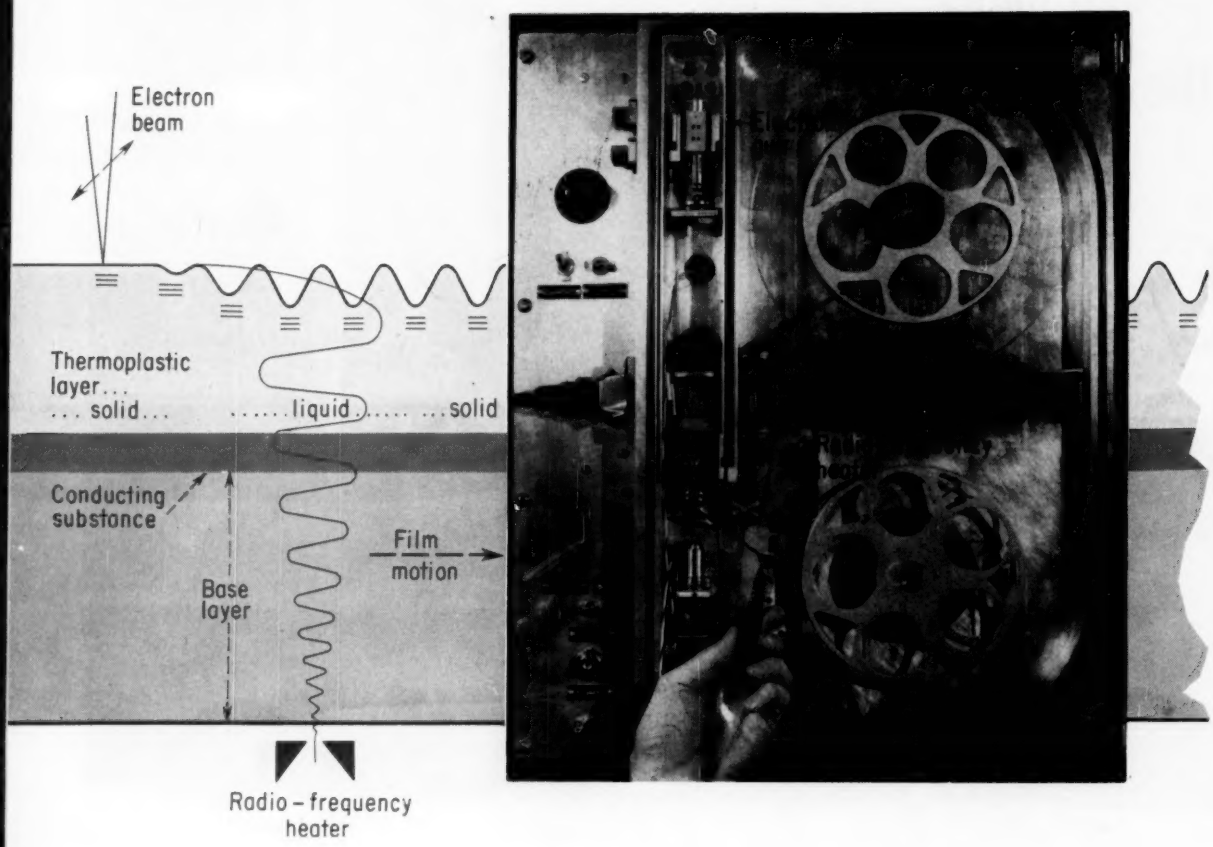


TPR: New Route to Ready Information

If current expectations prove out, GE's new Thermoplastic Recording may well rank in industrial importance with photography and magnetic recording.

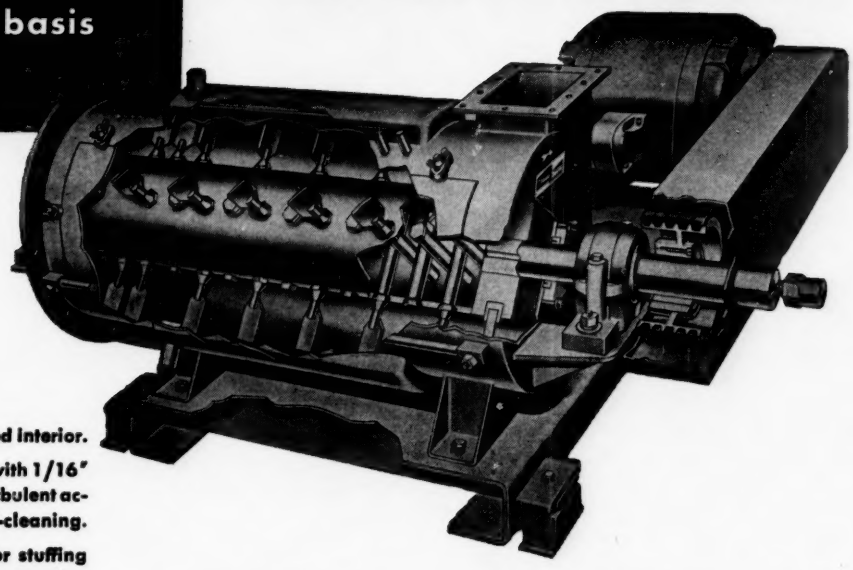
While "experimental Thermoplastic Recording (TPR) units will be in the hands of the military within the year," says a GE vice president, commercial applications are yet "quite a ways off." But whenever such commercial models do become available, it seems certain that chemical engineers in the process industries will be seeing a lot of them.

Simply described, TPR is a new recording system that uses electrons to convert information, including visual images, into microscopic wrinkles on a moving plastic film. According to GE's W. E. Glenn, inventor of the process, the system "combines the processing speed and much of the versatility of magnetic recording with the storage capacity of photography, and offers some advantages over both of these systems."

▶ **What TPR Offers**—More spe-

There's one sure way to get intimate mixing of dry and semi-dry material on a continuous basis

Strong Scott TURBULIZER®



EXCLUSIVE TURBULIZER FEATURES

- Heavy steel shell with machined interior.
- Paddles revolve at high speed with 1/16" clearance to shell, creating a turbulent action that makes Turbulizer self-cleaning.
- Choice of lip type, air purge or stuffing box seals. All are of split construction for quick disassembly. (Lip type seal shown.)
- Hinged door is machined as an integral part of the shell giving a perfectly smooth interior surface.
- May be equipped with jacket up to 150 PSI for heat transfer medium.
- Hollow rotor shaft for heat transfer medium gives added temperature control.
- Inlet nozzles available for adding liquids.
- Quick acting heavy lug type catches—no nuts or bolts to remove.
- Tangential inlet and discharge prevent material hang-up.
- Heavy duty outboard bearings.
- Rotating joints for easy connection to heat transfer medium source.

The Turbulizer solves many dispersion problems in the chemical and food industries. Adjustable-pitch paddles, revolving at high speed, result in the combined action of turbulence, shear and impact providing intense dispersion. These actions can be varied to obtain desired results on a specific material.

A completely smooth inner surface with 1/16" clearance paddles, assures thorough mixing, eliminates material hang-up, leaves no dead pockets of unmixed material and provides a self-cleaning operation.

In addition to the numerous features shown here, advantages of the Turbulizer include better product uniformity, increased production, plus lower labor, installation and up-keep costs.

Write for complete details...

Please send information on the Turbulizer

NAME_____

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COMPANY_____

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CITY_____ STATE_____

The Strong Scott Mfg. Co.

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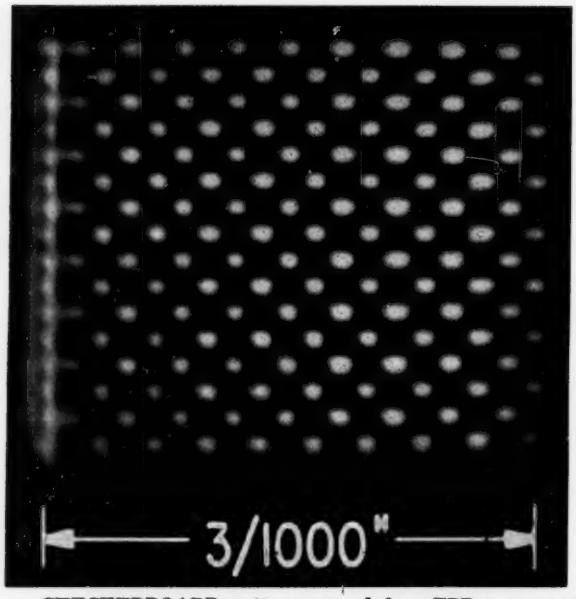
EQUIPMENT DESIGNED FOR BETTER PROCESSING



CHECKERBOARD pattern, recorded on TPR tape, contains up to 40 million bits of binary-digit information per square inch.

cifically, GE's device can concentrate 100 times more information in a given space than possible via magnetic recording. Resolution is high, chemical processing of the tape is not necessary, and "playback" techniques are relatively straightforward.

Data storage capacities achieved thus far run about 40 million bits/sq. in. And recording rates in excess of 50 million cycles/sec. are quite feasible.

Therefore, as *CE*'s *Chementator* speculated last month (*Chem. Eng.*, Feb. 8, p. 60), "it is conceivable that in a few years, TPR equipment the size of an office desk will store and retrieve entire libraries of reports, engineering drawings (black-and-white or in color) and technical data. And the implications of such storage densities with regard to computer applications in design or process control are immense."

▶**Recording Mechanics** — As schematically illustrated above, TPR film consists of three separate layers: The supporting bottom layer is similar to the base of a standard motion-picture film; the middle layer is a transparent electrically conductive substance; and the top layer is a thin coating of thermoplastic material.

During recording, an electron beam, modulated by information to be stored, lays down a pattern of charges on the thermoplastic surface of the moving film.

As the film travels on, a current induced (by radio-frequency heater) in the conducting middle layer causes the thermoplastic to melt. As a result, surface charges become free to move toward the conducting layer under influence of electrostatic forces. This action deforms the film's surface in an intelligence-bearing pattern of wrinkles.

Immediately after surface deformation, the film cools and the thermoplastic solidifies—ripples freeze in place. Subsequent erasure of the record involves temporary reheating to allow surface charges to leak away; surface tension restores the film to an unwrinkled, reusable condition.

▶**Optical Playback**—In order to read or retrieve ripple-stored information from TPR tape, an optical playback system is required. For black-and-white information, the playback mechanism is a modification of a Schlierien optical system.

Playback mechanism components are essentially the same as those for a standard movie projector. However, instead of a plane light source, the TPR projector uses a series of parallel, horizontal, line-type light sources. These are imaged on a set of bars in front of the projection lens in such a way that, when no TPR recording is in place, no light reaches the screen.

But, if recorded tape is interposed between condensing and projection lenses, the film's ripples will scatter light through the bar system to form a screen image of stored information. Photoelectric techniques can produce electrical playback when required.

For color recording, the recorder uses a special electron gun to impress deformations on the thermoplastic surface in the form of phase diffraction gratings. Playback from such records requires a more refined optical system (W. E. Glenn, *J. Am. Optical Soc.*, Nov. 1958).

—General Electric Co., Schenectady, N. Y. **82A**

Instant Pipe

Ditch-walking machine lays "instant" concrete pipe.

Construction machinery that builds "instant concrete pipe" in a freshly-cut ditch at the rate of 8 to 12 ft./min. has been developed for pipe sizes between 12 and 48 in. Typical applications include erection of irrigation-water lines, storm sewers and drainage piping.

Machinery consists primarily

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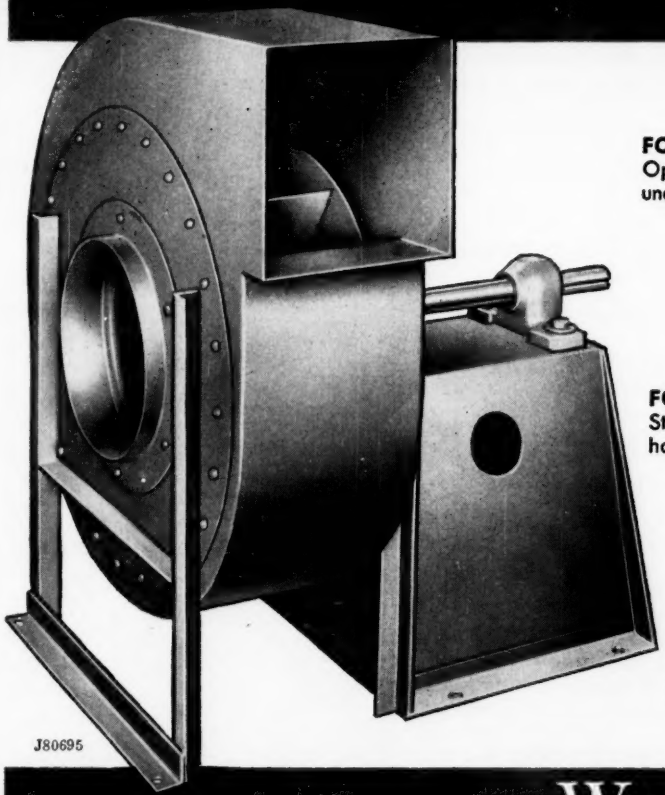
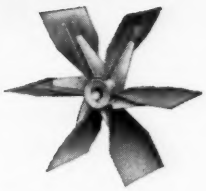
NEW Westinghouse Industrial Fans Do All These Jobs Better

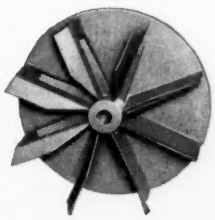


J80695

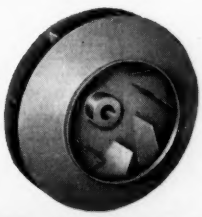
FOR MATERIAL HANDLING: Open radial blade wheel with unobstructed air passages.



FOR STRINGY MATERIALS: Strong backplate wheel easily handles fibrous materials.



FOR EXHAUST, CIRCULATION: Improved design with backwardly inclined blades for low horsepower.



Westinghouse

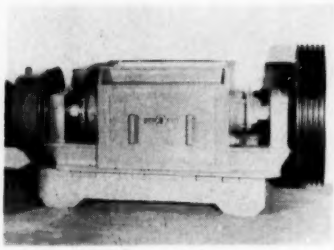
of a double-hoppered forming unit that is pulled along the rounded bottom of a ditch, while enveloping an inflated rubber-fabric form. Half of the double hopper, activated by electrically-driven tampers, shoves concrete into the bottom of the ditch, while the other half forms the top of the pipe over the inflatable tube. About 2 hr. after pouring, the inflatable form is deflated and extracted for reuse.—**Fullerform Continuous Pipe Corp., Phoenix, Ariz.** 84A

Aerosol Monitor

Continuously checks on atmospheric particulates.

A new atmospheric-particle counting instrument provides, on a strip-chart recorder, permanent records of aerosols present in a given atmosphere. Over-all range extends from 0.3 microns to any desired upper limit. Each record is differentiated into 15 sub-ranges and recorded in sequence at predetermined intervals. Because the unit is continuously self-calibrated, stability problems are nonexistent.

Included in the instrument is an alarm system that can be set for remote indication of particle concentration in any of the monitor's sub-ranges exceeding a predetermined maximum. Known as the PC-200, the monitor has a counting rate of 1,000 particles/min., with 1% coincidence loss at the standard flow rate of 100 cc./min.—**Royco Instruments Inc., Mountain View, Calif.** 86A



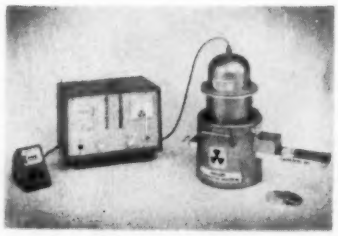
Crusher

Watertight unit handles chemical slurries.

Designed so that all material in contact with slurries being processed is made of stainless steel, a new watertight sawtooth crusher can withstand 20-ft. liquid head pressures.

In order to bear such pressures, all bearings are outboard. The stuffing box for the shaft seal is extra heavy, and neoprene gaskets protect covers, inspection doors and other parts where leakage might occur.

Instead of square or hexagonal main shaft, the new crusher utilizes a round shaft for extra strength. The 85 saws ($\frac{3}{32}$ in.) are Type 403 stainless. —**Sprout, Waldron & Co. Inc., Munsey, Pa.** 86B



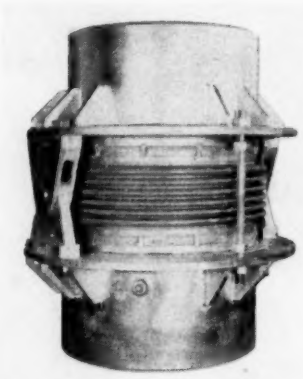
Beryllium Analyzer

Radiation technique detects element in any form.

Designed for research, development or processing applications, the new Model 200 analyzer measures beryllium content of this element's alloys or compounds to an accuracy of 0.02%. The instrument utilizes a nuclear reaction (Gamma + Be^9 gives Be^8 + neutron) as a means of detection.

In operation, gamma rays from an antimony radioisotope bombard the sample. Ejected neutrons are moderated, and then detected with a scintillation phosphor. Light scintillations, converted to electrical impulses that are counted with a scaler, are compared with counting rates from a known sample.

Quantitative analyses for beryllium content take about 3 to 5 min., and qualitative analyses take less than 1 min. It is not necessary to operate the instrument within a restricted area.—**Boulder Scientific Co., Boulder, Colo.** 86C



Expansion Joints

Hinged to make piping systems self-supporting.

Developed for piping systems that cannot be supported or anchored by conventional means, a new series of hinged expansion joints make it possible for a piping system to be entirely self-supporting. The joints can readily carry shear loads and can absorb piping weight, wind loads and other dead loads without extensive anchoring.

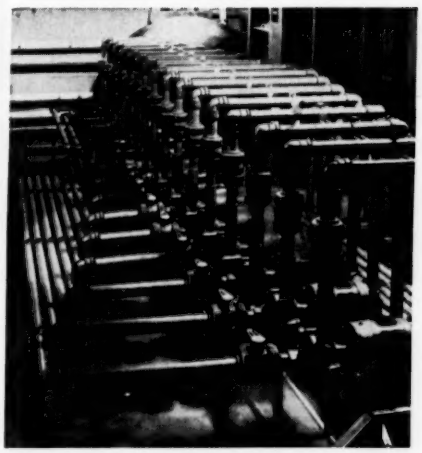
A standard model of a hinged expansion joint will take rotation in one plane only. For this reason, hinged expansion joints are used in combinations of two or three. Slotted hinges are

EQUIPMENT NEWS
Continues on . . . Page 178

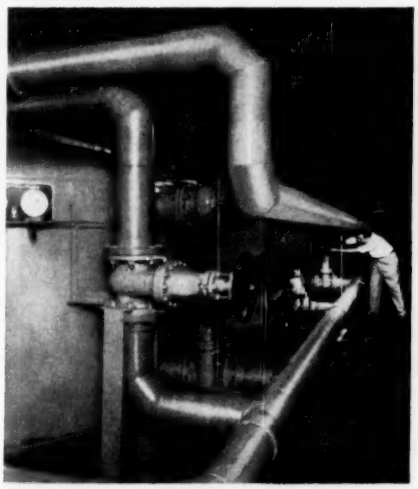
FREE—NEW 36 PAGE TECHNICAL HANDBOOK ON PVC PIPE—SEE COUPON

NOTHING PIPES LIKE KRALOY PLASTIC PIPE

no rust, no rot, no corrosion...
no other pipe does the job so trouble-free
so permanently, at so little cost!



KRALOY PVC Plastic Pipe with plastic valves and fittings installed in the photographic laboratory at the U.S. Air Force Missile Test Center, Patrick AFB, Florida. KRALOY is unaffected by most all common acids.



Swimming pool water filters as installed at one of the leading Miami Beach hotels using 6" KRALOY PVC Plastic Pipe. Note solvent-welded joints to fit all requirements of the installation.

Industry's toughest piping problems are being solved faster, more easily and more economically than ever before by today's great trend to KRALOY Plastic Pipe. Engineers and contractors have found that KRALOY PVC Plastic Pipe meets virtually every piping need and solves corrosion and maintenance problems that no metal pipe or other materials can handle.

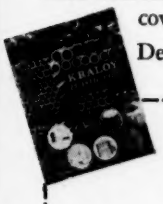
Unaffected by electrolysis, highly resistant to salt water scale and most all common acids, KRALOY not only avoids rust-outs and metal deterioration failures—but most important in meeting budget specifications, it is cheaper to install and maintain.

Light in weight (⅛ that of steel), KRALOY's ease of making joints and bending simplifies transportation, handling and laying—*saves up to 50% on installation costs!*

SMOOTH WALLS = HIGHER "C" FACTOR, FASTER FLOW

Quality protected by continuous laboratory control—today's KRALOY Pipe provides both normal and high impact strength. Precision extruded, KRALOY'S smooth, highly polished mirror-finish walls reduce friction, permit faster, freer flow that delivers up to 20% greater volume than metal pipe... even permits use of smaller pipe sizes! And KRALOY *permanently retains* these superior flow qualities. Underground or aboveground—for liquid or use as conduit—when your requirements call for long life, corrosion and trouble-free pipe—specify KRALOY PVC Plastic Pipe. Available in all sizes from ¼" to 12" with plastic valves and fittings.

Send for KRALOY's new FREE 36 page Technical Handbook on PVC pipe... filled with information including flow charts and a corrosion resistance chart covering more than 160 acids. Kraloy Plastic Pipe Co., Inc., Dept. ChE-3, 402 W. Central Avenue, Santa Ana, California



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Kraloy Plastic Pipe Co., Inc., Dept. ChE-3,
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Gentlemen: Please send me a copy of your new FREE 36 page Technical Handbook on PVC pipe.

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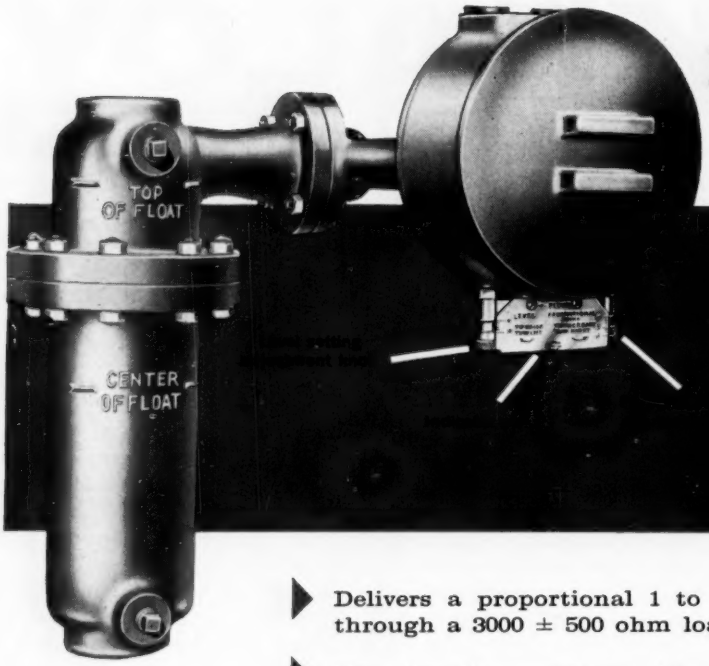
NOW FISHER LEVEL-TROL®

FOR ELECTRONIC SYSTEMS

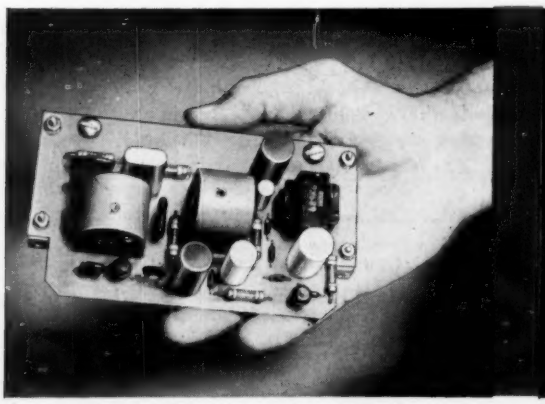


Quick accurate external adjustment

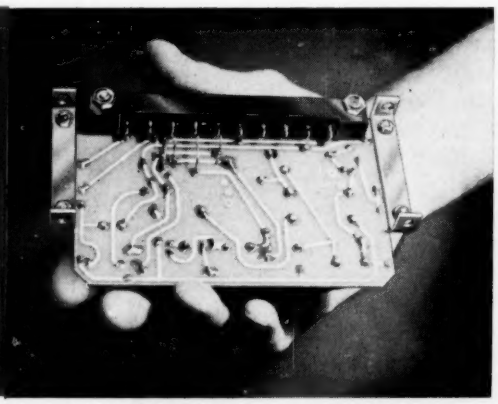
- **Delivers a proportional 1 to 5 milliampere dc signal through a 3000 ± 500 ohm load.**
- **Has plug-in converter with printed circuit. Conventional leads and unnecessary wiring are eliminated.**

This Fisher explosion-proof Electronic Level-Trol features external adjustment for proportional band and liquid level height, and incorporates extreme simplicity of design throughout. Silicon transistors and diodes are used instead of the conventional vacuum tubes. You do not need any additional parts to reverse action of the unit. With only .25% effect from ±15% supply voltage change, line voltage fluctuation is of negligible effect.

Fisher Bulletin F-85 will give you complete details on the Fisher Type 2300 Electronic Level-Trol. Send for it.



Plug-in electronic converter assembly.



Printed circuit of the converter assembly.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

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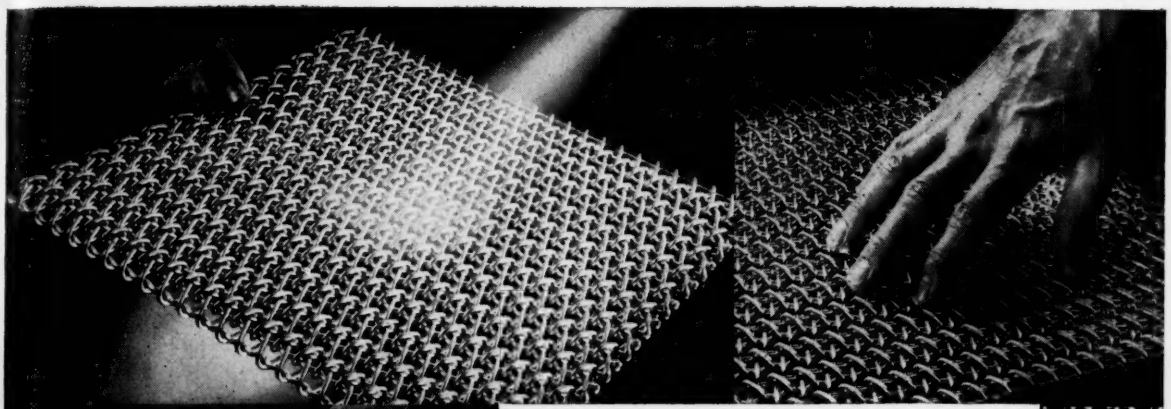

These characteristics of

CAMBRIDGE METAL-MESH BELTS

give you fast, low-cost, uniform chemical processing

Whatever you process or package — slab, sheet, pelletized or powdered materials — Cambridge Metal-Mesh Belts combine movement with processing to give you greater production and consistently high quality without costly manual handling.

Open mesh construction allows heat, cold or liquids to flow through the belt and around the product for fast, thorough processing. Liquids drain off quickly, completely. Superior belt design and manufacturing techniques mean longer belt life, fewer repairs, lower operating costs. Smooth belt surface has no sharp edges; can be easily cleaned. Belts can be made heatproof, coldproof, acid proof — in any mesh, weave, metal or alloy — with any side or surface attachments.

Call your Cambridge Field Engineer now. He'll be glad to discuss any aspect of Cambridge Belts — from manufacture to installation and service. Look in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

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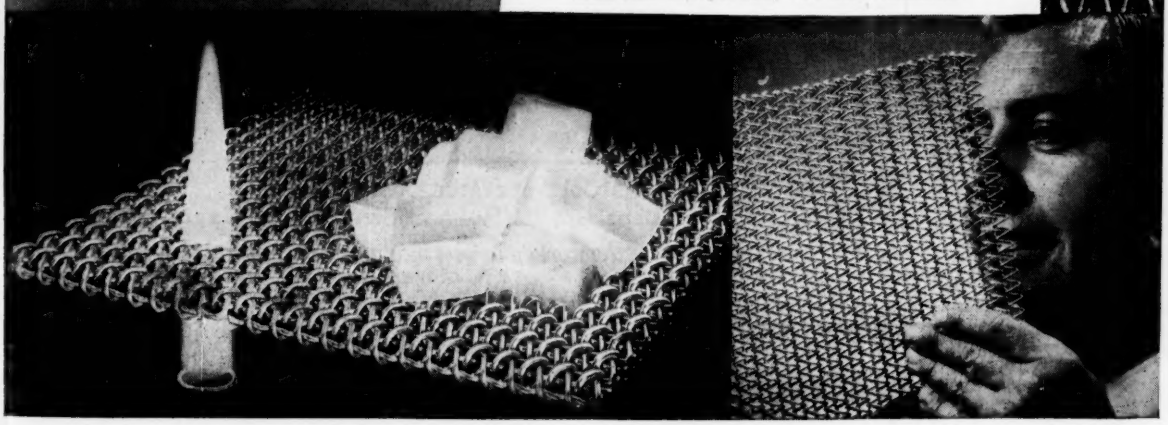
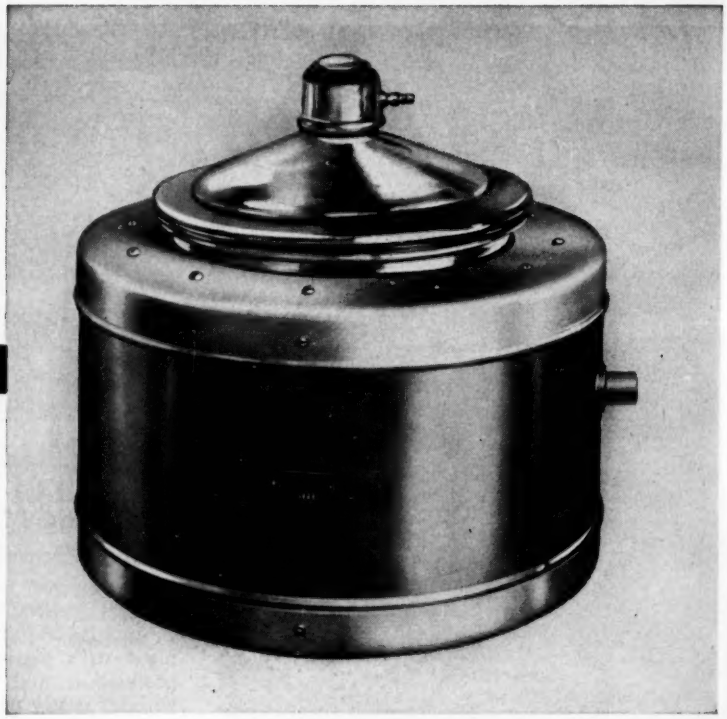
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications





For a small cost, you can convert your Desiccator into a vacuum drying oven

. . . it assures even heating which minimizes chance of thermal strain to glass vessels.

. . . it provides an effective shield for personnel in the rare instances when glass vessels do collapse.

This new, aluminum-housed electric heating mantle is specifically designed for heating heavy-walled vessels in which vacuums must be created to permit the drying of various samples.

As a result of the high pressure due to conditions of high vacuum, heavy-walled vessels occasionally collapse. When such accidents happen, the Glas-Col aluminum-housed heating mantles provide a very effective shield to protect personnel from flying glass and chemicals.

Glas-Col mantles have been used to heat desiccators for several years . . . with *complete* success.

Glas-Col Desiccator mantles are priced from $45.00 to $57.00

Catalog No.	Desiccator Flange Diameter	Watts (115 Volts)	Price
M-200	160 mm	330	$45.00
M-202	200 mm	380	57.00
M-204	250 mm	380	57.00

Glas-Col Apparatus Company
Dept. CR, 711 Hulman Street, Terre Haute, Indiana

. . . the world's largest manufacturer of heating mantles

U.S. Patents 2,282,078 2,739,220 2,231,506 and 2,739,221

GLAS-COL ELECTRIC HEATING MANTLES

A complete line for laboratory, pilot plant, and chemical process heating applications.

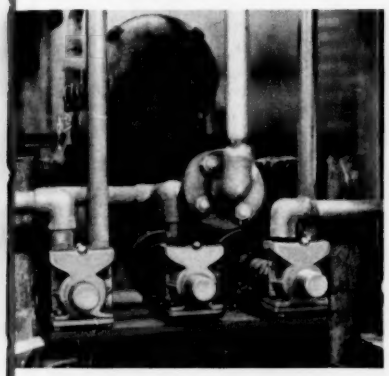
ECO ENGINEERING NEWS

the big name in small pumps for the process industries

Pumping Notes

•

Mallinckrodt Nuclear Corp. Gives ALL-CHEM Pumps Tough Job . . .



The battery of three ALL-CHEM Pumps shown above, driven by a single motor, is being used on a continuous, countercurrent extraction system. They are pumping tri-butyl-phosphate, kerosene and 3N nitric acid.

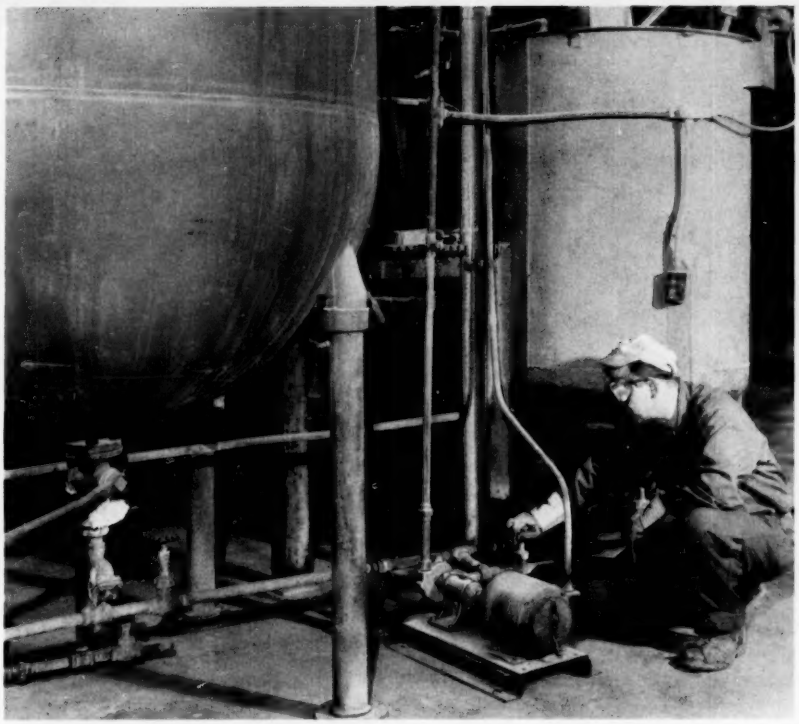
These ALL-CHEM Pumps are 304 stainless steel with Teflon† impellers and bearings and special Teflon and Halocarbon packing.

Though the nitric acid is extremely corrosive and the tri-butyl-phosphate is extremely hard to contain—these pumps and their packing are performing well on the job.

Eco Pumps Shown at Swiss Exposition

The ILMAC Exhibit recently held in Basle, Switzerland, is one of the most important held in Europe, pertaining to chemical equipment.

This official Eco Exhibit was conducted by our Swiss distributor, Mr. Henry C. Iseli.



CENTRI-CHEM Pump Provides Satisfaction to Largest Producer of Tin Chemicals

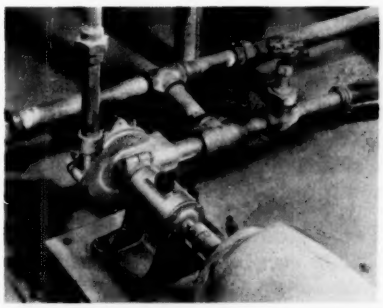
Metal and Thermit Corporation, Carteret, New Jersey, not only is the largest producer of tin chemicals in America—such chemicals as stannic chloride, stannous oxide, bismuth and barium stannates—but they also are engaged in the largest de-tinning operation from tin plate scrap in the country.

In these processing operations, it is obvious that some very difficult acids, caustics and slurries must be pumped.

In 1956 this company decided to try an Eco PTA-4 CENTRI-CHEM Pump for transfer of bismuth nitrate in excess nitric acid at ambient temperatures. This pump was also required to pump caustic solutions on occasions.

The CENTRI-CHEM Pump has now been continuously employed for three years on intermittent pumping service giving completely satisfactory operation. During these three years, only one basic repair has been required, which was the replacement of the mechanical seal.

Eco CENTRI-CHEM Pumps feature Type 20 stainless steel throughout—casings, shafts and impellers—which is the reason why they meet such a wide range of corrosive service.

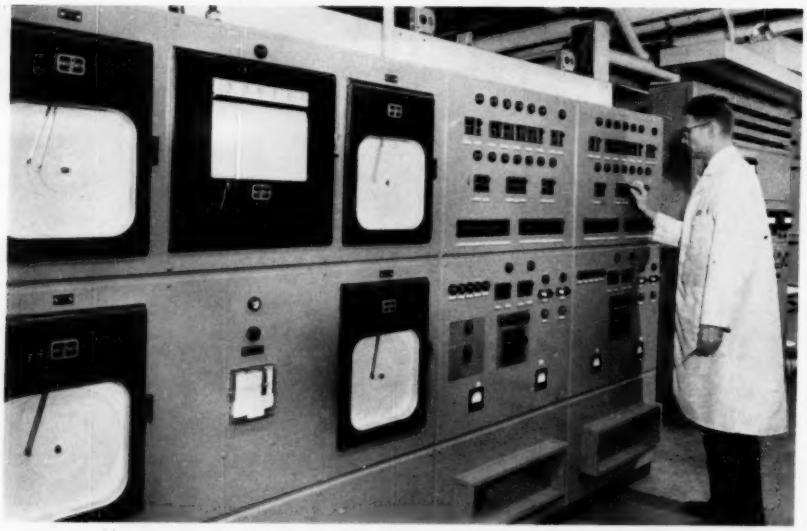


The mechanical seal used in CENTRI-CHEM Pumps has proven serviceable and leakproof within temperature ranges from minus 150°F to plus 450°F. It is simply constructed and easily maintained.

Seal components to meet various exposures include Teflon and ceramic, carbon and ceramic, and carbon and Type 20 Stainless or Stellite*. These components are dimensionally interchangeable.

*Union Carbide Trademark. †du Pont Trademark.

Eco Pumps Help Film Finisher Save $12,000 Worth of Silver, Annually



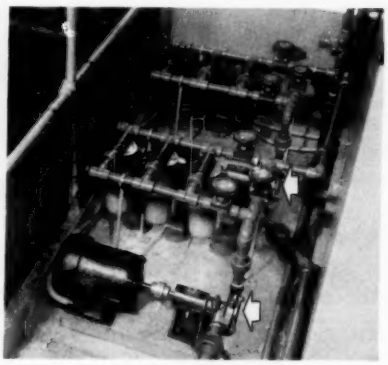
Control Engineer Spencer B. Fulweiler at one of the instrument panels from which all Film Finishing operations in this precision laboratory are controlled.

The Berkey Photo Service, Inc., with offices in New York, Boston, New Haven, Chicago and Detroit, is the largest independent color and black-and-white film finishing company in the world. More than 350 people are employed in the New York laboratory, alone.

For greatest efficiency this huge film finishing laboratory has been completely automated to insure exceptional quality control and maximum economy of operation.

For the reclamation of excess silver from the fixers, Berkey engineers, last May, installed a fixer recirculating system utilizing silver recovery cells and three Eco CENTRI-CHEM Pumps.

Two of these pumps have been in continuous service, 24 hours of the day, seven days of the week, since May 1959 without a single maintenance problem. The third pump is installed as a stand-by.



Two of the three Eco CENTRI-CHEM Pumps which recirculate the fixer through silver recovery cells.

Engineer Fulweiler who installed these pumps states that this silver recovery system is saving at the rate of $12,000.00 worth of silver annually.

ECO Products for Handling Corrosive and Hazardous Processing Fluids

ALL-CHEM® Rotary Pumps
MINILAB® Rotary Pumps
GEARCHEM® Gear Pumps
CENTRI-CHEM® Centrifugal Pumps
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The "Who Pumps What With Eco" Department

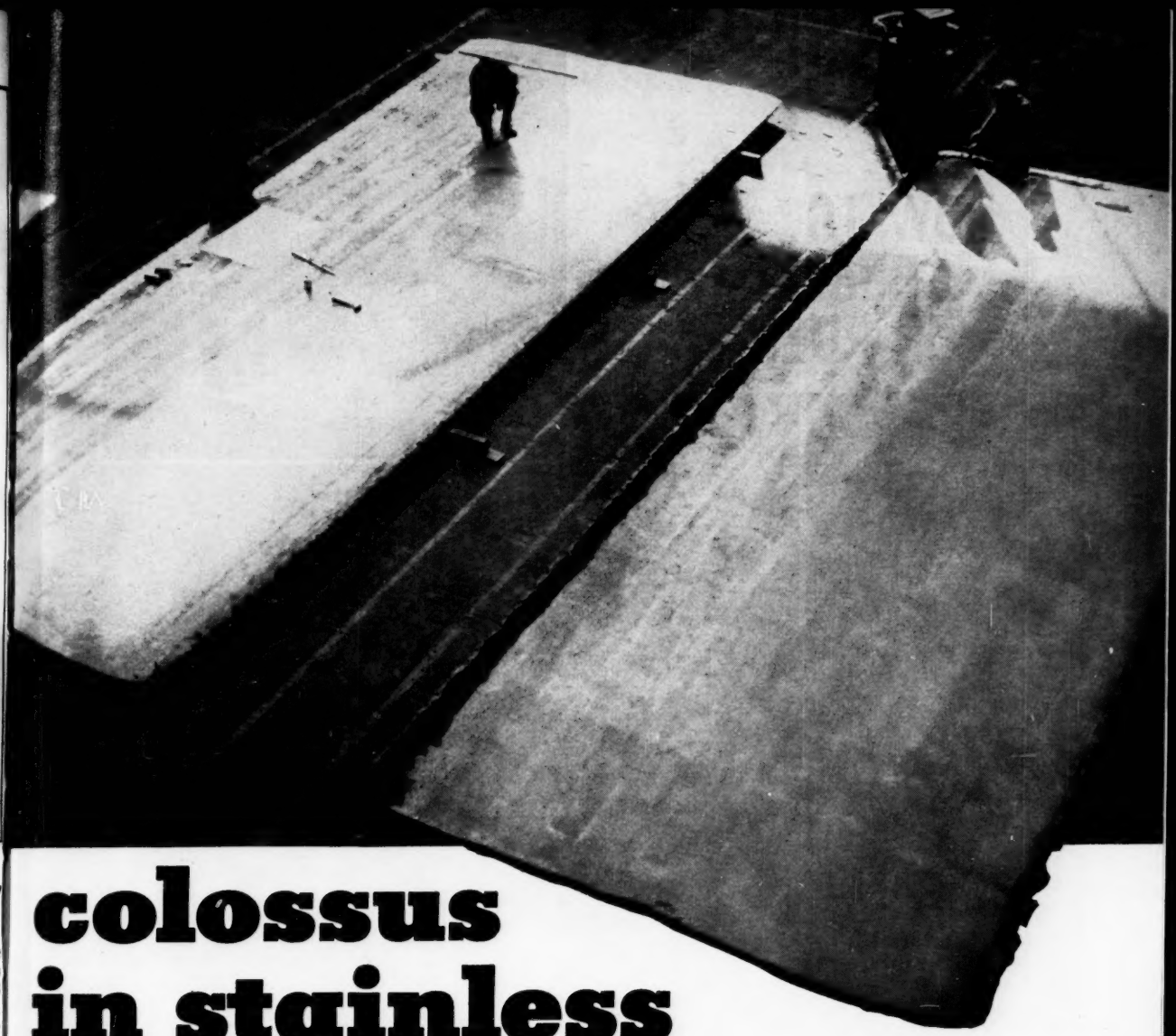
Example: Gesellschaft fur Angewaudte Chemie A. G., Baden, Switzerland, has operated an Eco ALL-CHEM Pump, 316 stainless steel construction with Teflon impellers, for the handling of phosphoric acid at room temperature, for two years.

During this period, the pump has handled over 25 metric tons of this acid. The only repair required was one replacement of the Teflon impellers.

Example: Sylvania Corning Nuclear Corporation, Hicksville, L.I., New York, have repeatedly purchased Eco ALL-CHEM Pumps in 316 stainless steel with Teflon impellers, bearings and packing for handling hot nitric acid solutions at temperatures near 180°F.

Example: Radio Corporation of America, Lancaster, Pennsylvania, have purchased Eco Pumps for a number of years. These include both ALL-CHEM and GEARCHEM types for a variety of services covering caustics, acids, etc.

Example: Chesebrough-Ponds, Inc., Clinton, Connecticut, well known for Vaseline products and cosmetics, have operated a number of pedestal mounted CENTRI-CHEM Pumps as well as 316 stainless steel ALL-CHEM Pumps for several years. Media pumped range from lotions to solvents to emulsions, etc.



colossus in stainless

...world's largest stainless steel plates ready for processing at Carlson

SOMETIMES Carlson service is a cooperative venture that gets practically impossible jobs done. The processing and finishing of these, the world's largest stainless steel plates, is an example of such teamwork.

As this was a "first time" job, the most careful planning and coordination had to be exercised. Oversize ingot molds and a 70-ton capacity furnace had to be used. It took the country's largest plate mill to roll the ingots to slabs, the slabs to plates. The finished plates, cut-to-shape by Carlson specialists, met every customer requirement.

These huge plates, of Type 304 stainless steel, were made to Specification A-240 Grade S (ASTM A240-T). Each plate weighed over 49,000 pounds; one measured 461" x 179" x 2"; the other 451" x 184" x 2". Destined for a nuclear application, these plates were flame-cut and abrasive-cut to make two half-circles. The entire order totaled nearly 100,000 pounds.

Cooperation made this "colossus" a success—cooperation under the knowing eyes of Carlson specialists. This same team is ready to work on your order. We invite you to write, wire or phone for further information.

G.O.CARLSON Inc.

Stainless Steels Exclusively

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THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

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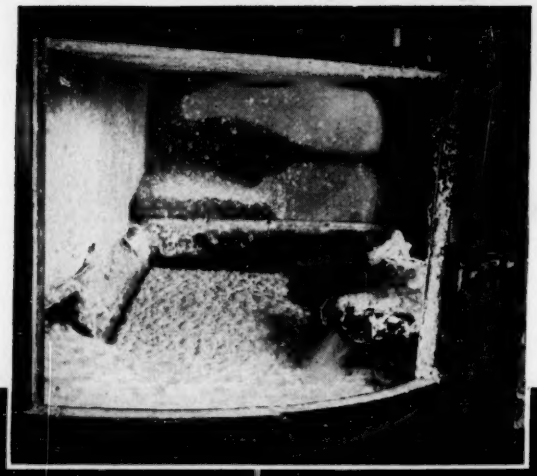
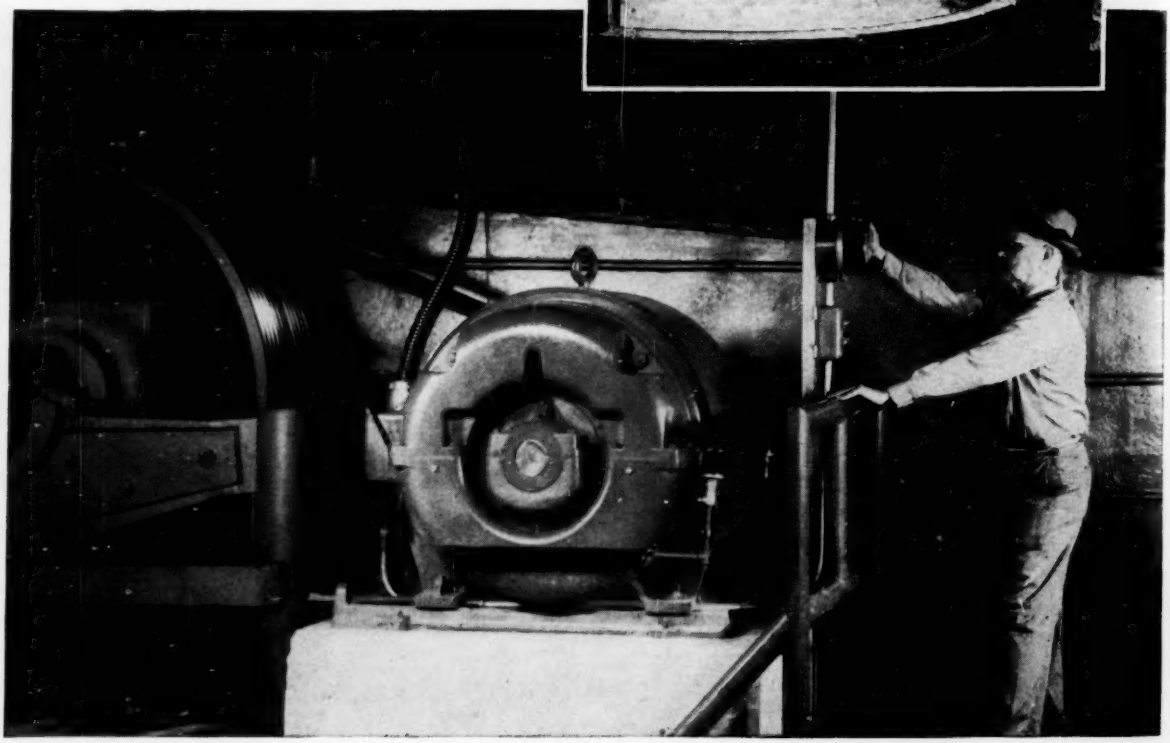
HOW TO BEAT A TON OF PULP...





ALTON

Alton Box Board Company is one of America's most complete paperboard and packaging organizations.

The manufacture of paperboard, basic component of folding cartons and corrugated and solid fibre containers, is a complex process requiring massive machinery driven by powerful motors.

This top liner finishing beater, for example, is a giant "mixer" that beats 2000 pound batches of kraft pulp, mixed white paper, clays and water to form a highly liquid pulp. It is driven by a Wagner 150 hp low speed splashproof motor. The endplates are built in two sections to provide ready accessibility to the sleeve bearings.

Whatever your motor requirements may be, Wagner can build a special motor, or provide a standard motor to fit your need. Wagner builds motors in ratings through 1000 hp, with a wide variety of enclosure types and mountings. Call your nearby Wagner field engineer for an engineering analysis of your next motor application. There are Wagner branches in 32 principal cities.

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It takes 64 gallons of H_2O to make one gallon of H_2SO_4

To make 200 gallons of sulfuric acid you need approximately 12,500 gallons of water.

It would take just *two minutes* for a twelve-inch Goulds Fig. 3405 to supply it. This medium-size pump provides giant-size capacity: 6400 gallons per minute!

And to keep water flowing, you stock only a minimum of spare parts. Just three groups of parts fit thirty-three sizes of the 3405. All parts are interchangeable except casings, casing covers and impellers!

That means that for every three to five pumps of a given group size, you stock just one shaft, one set of bearings, sleeves, mechanical seals or packing. You can cut inventories as much as ninety-one percent, yet be fully covered for emergencies.

Heads go up to 425 feet. For more data, write to Goulds Pumps, Inc., Dept. C-2, Seneca Falls, N. Y., for Bulletin 721.6.

GOULDS PUMPS

This Bailey Instrument measures both oxygen and combustibles!

You can measure oxygen and combustibles with this Bailey Analyzer-Recorder . . . at less than the price of other instruments that make only single measurements.

Bailey gives you a continuous recording of *both* on the same chart for quick, simple comparison.

Speed of response is second to none . . . due to the catalytic combustion measuring unit and a high speed sampling system.

Accurate analysis and stable calibration enable the operator to keep fuel-burning equipment performing continuously in the zone of maximum combustion for greater throughput. It is possible for fuel savings, alone, to pay for the instrument.

A Bailey Engineer will be glad to call at your plant and explain how this and other advanced Bailey instruments and controls can help you to greater processing efficiencies. Or write our Chemical and Petroleum Division.

Bailey Analyzer-Recorder at petro-chem furnaces of Continental Oil Company, Westlake, La.

CP108-1

Chemical and petroleum division

BAILEY METER COMPANY

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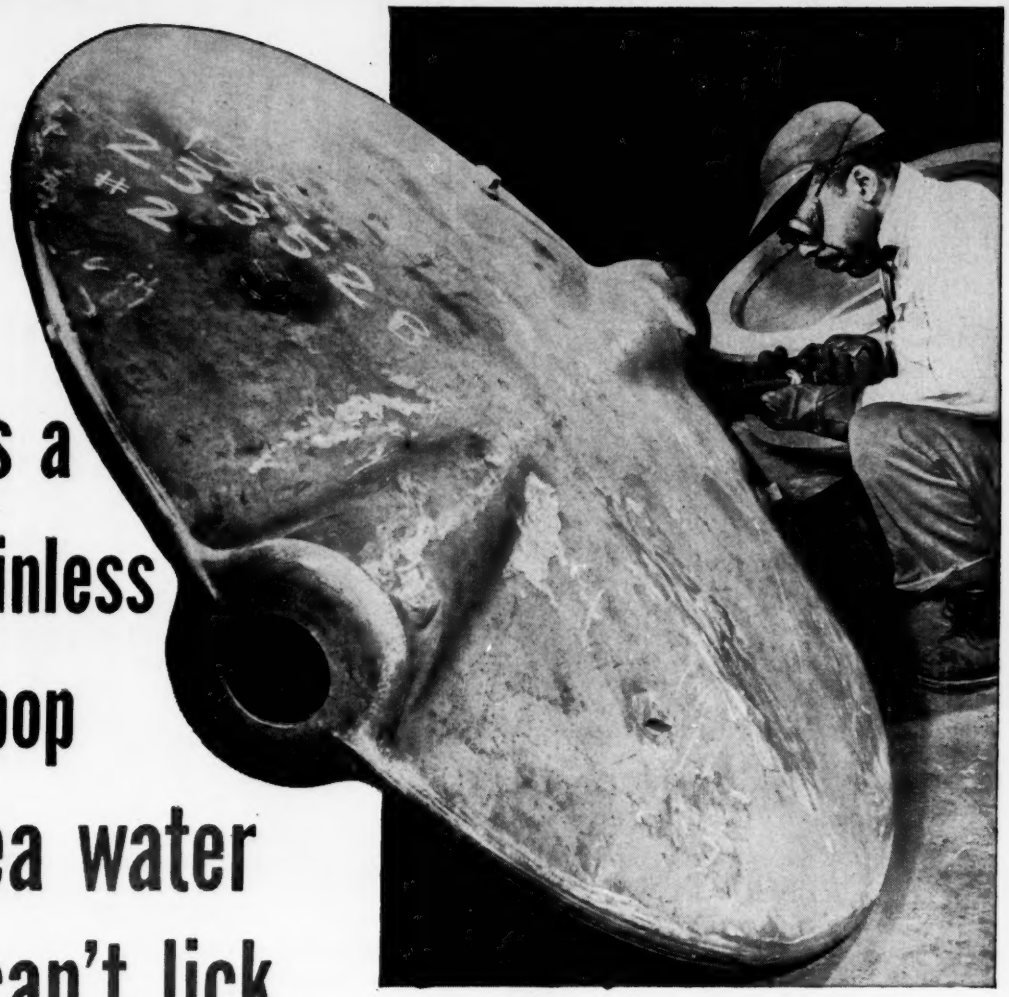
In Canada—Bailey Meter Company Limited, Montreal



Here's a stainless lollipop sea water can't lick

This large (48″ dia., 1701 lbs.) and unusual stainless casting was fabricated by Allegheny Ludlum's Buffalo, N.Y. foundry. It is scheduled for service under the most severe operating conditions, functioning as a wafer valve disc at 25 psi pressure in sea water. Since long life and tight closing are essential in this application, corrosion resistant Type 304 Allegheny Stainless was specified.

Some unusual techniques were employed in the fabrication of this casting. Although the entire valve disc was cast as a single piece, its sides are hollow, with a skin only ¾″ thick. The center shaft was cast solid at the same time the side wings were cored, permitting the single piece, seamless part desired.

If you have a casting problem, or *any* problem that involves corrosion resistance, long life, resistance to wear and abrasion, call the Allegheny Ludlum Sales Office nearest you. An A-L Sales Engineer is ready to put his skills and those of the A-L Technical Staff promptly at your disposal, to serve your requirements from the largest and most complete line of stainless products on the market.

Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania.

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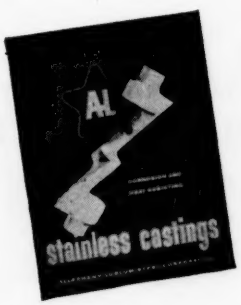

Write for this 28-page booklet on A-L STAINLESS CASTINGS

28 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

ADDRESS DEPT. CE-27

Make it BETTER and LONGER LASTING with

ALLEGHENY STAINLESS

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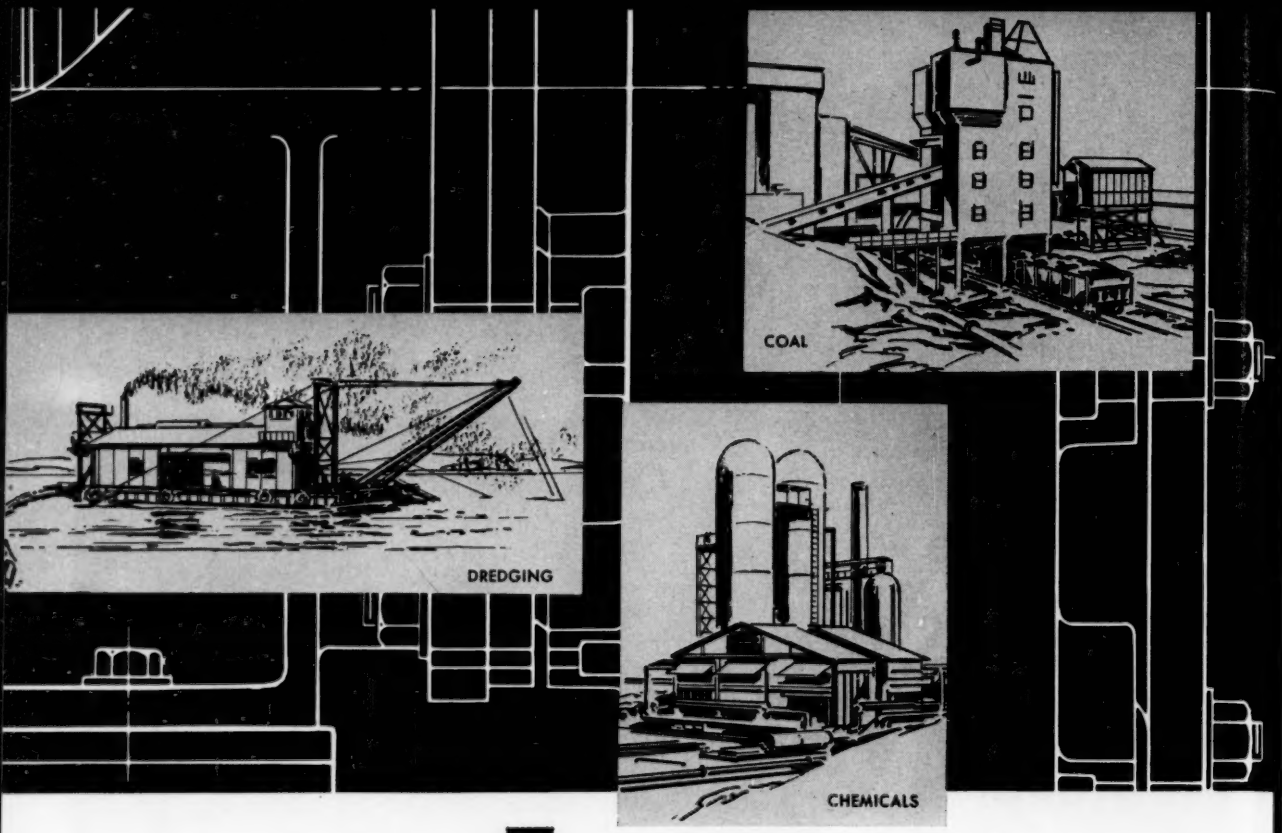
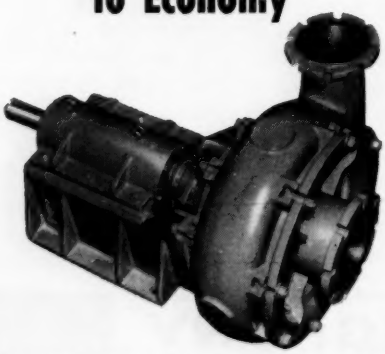


MORRIS
CENTRIFUGAL PUMPS

Wherever Sustained Pumping Performance is the Key to Economy



Type CK Solids Pump. A heavy duty, low speed solids pump with extra wide clearance, designed especially to handle fluids containing random size solids and heavily abrasive materials.

If you are pumping chemical process slurries or wastes, there is a Morris Pump that will do the job dependably and economically.

Because they are often located in inaccessible areas where service needs must be few and far between, Morris pumps are designed to operate at highest efficiency, *constantly*. Morris pump reliability is based on quality features developed during 95 years of hydraulic design and testing experience.

Field testing has evolved the most exacting engineering of component parts . . . the correct selection, forming and machining of just the right alloys for each application . . . and pumps that are rugged, long-wearing and trouble free. Every part of every Morris Pump is accessible for fast, routine service—holding preventive maintenance to a minimum.

Let the qualified Morris Representative in your area help you select the right Pump for your job. Representatives in principal cities or write direct.

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Baldwinsville, N.Y.

SALES OFFICES IN PRINCIPAL CITIES
EXPORT OFFICE: 50 CHURCH ST., NEW YORK 7, N. Y.

KENNEDY Coke-calcining Kilns

Mountaineer Carbon Company achieves higher yields and better quality at their new Cresap, W. Va. coke-calcining plant—with a KENNEDY Kiln and KENNEDY Kiln Accessories.

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Mountaineer averages better than 75% yield, several percentage points higher than older installations. And the coke is more uniform in density.

Mountaineer gains these advantages through close control of combustion. A single gas-fed burner in hood at discharge end of kiln generates a temperature of about 2,500 F. Flame configuration, primary and secondary air flows are all controlled carefully; seals cut leakage of unwanted air.

This close control of combustion allows some burning of cracked gases from coke bed. Yet, it prevents unwanted combustion of carbon which reduces yields in most coke calcining. Too, it produces uniform density in finished product, a direct result of uniform temperature.

Kiln is 180 ft. long and 10.5 ft. in dia. Rotating at about 1 rpm., it retains coke approximately 100 min.

KENNEDY equipment is behind the high performance record of this new plant:

- The 180′ long kiln with its bronze sleeved, self-aligning bearings, 3-tire supports and drive assembly;
- Special feed and discharge air seals which reduce air leakage and improve combustion control;
- The kiln firing hood with its extra large access doors for maintenance;
- The air cooled nose ring assembly, specially designed by KENNEDY for coke-calcining.

When you are in need of kilns—for lime, calcined coke, dead burned dolomite, cement by wet or dry process, nodulizing and agglomerating or drying—consult KENNEDY. You can be assured of quality equipment that delivers high, long-lasting performance.

See pages 407-411 in your Chemical Engineering Catalog for a full listing of Kennedy Products for the Chemical & Process Industries

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MANUFACTURING & ENGINEERING CORPORATION

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NOW... prompt delivery from mill stocks!

Stainless Heat Exchanger Tubes

Save time in getting Types 304 and 316 heat exchanger tubes for new units or re-tubing jobs. Call your nearest Carpenter office for prompt delivery from large mill stocks of sizes ⅜″ to 1″ O.D. in 18 and 16 BWG. Stock lengths up to 40 feet are cut to your specific requirements. These full-finished tubes fully meet ASTM Spec. A-249. Besides, they pass the most searching non-destructive test applied to stainless tubing anywhere. This extra-close quality control is your assurance of getting the highest possible degree of perfection and dependability in Carpenter Stainless Tubes. That means savings in time, money and trouble for builders and users of heat transfer equipment.

If you need other standard or special-purpose types of heat exchanger tubes, Carpenter can supply them also. Our technical staff is always available for competent assistance on any stainless tubing or pipe problem. For prompt service on your next orders, contact your Carpenter representative or the mill. The Carpenter Steel Company, Alloy Tube Division, Springfield Road, Union, N.J.

your master key to cost-saving corrosion control

Carpenter

Stainless Tubing & Pipe

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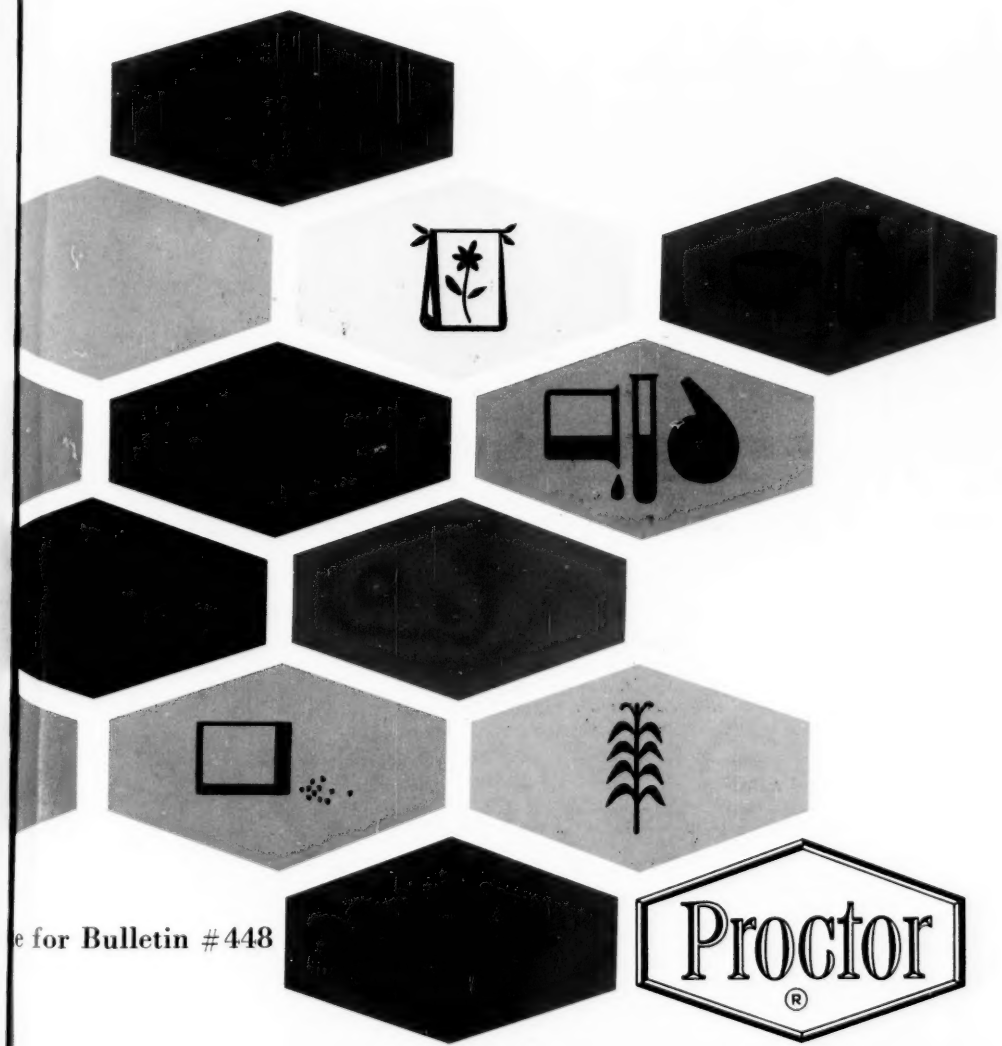

e for Bulletin #448

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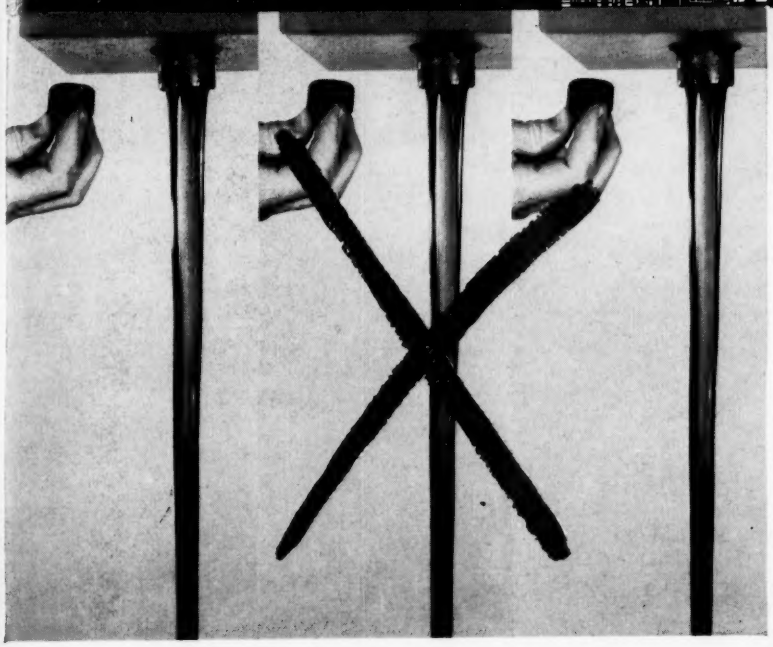
LUBE LOGIC

3 WAYS TO IMPROVE EQUIPMENT PERFORMANCE

TEXACO



How to cut drain periods yet improve hydraulic performance!

Drain periods for a hydraulic system may be extended many times over by switching from straight mineral oils to a premium oil.

This has been proved time and again when the switch has been made to Texaco Regal Oil R&O without altering any other operating conditions.

It's obvious that draining hydraulic systems, cleaning, and replacing with new oil is costly. If one or more drainings can be eliminated the additional oil cost would be warranted.

Straight mineral oil may be satisfactory for some systems, but tests show that Regal Oil R&O can extend the interval between draining at considerable savings. This premium oil is formulated to resist oxidation, rust, foam, and wear.

And there's a bonus! When you do drain, you'll find the system in cleaner condition. You'll save again on make-ready.

Watch out for bumps and grinds in gear boxes!

When the enclosed gears in your plant start making noises like an overloaded washing machine, it's likely to cost your company some money. That's because you're probably listening to severe wear on gear teeth.

Make a quick check of the alignment and the clearance between the gear teeth. Then, check the bath level of the oil. If it's too low, the gears will just "slap" into it. What you want is a paddlewheel action that will keep the gears covered with the lubricant.

If there's still noise after your check, it will pay you to call in a TLE*.

One way to prevent bearing failures

Preventing bearing failures before they develop is often just as easy as getting reports from Production Management. In fact, that's how you do it. When you find that Production has made a change in operating conditions, or an adjustment in process equipment, that's your signal for action.

First step is to determine whether or not the bearings can take the new operating situation. You'll want to check for changes in temperatures and loads, for increased moisture and dust, and for extra exposure to corrosive materials.

Second step, equally important, is to make sure the grade of lubricant you've been using still fits the new conditions. Your TLE* can show you how to determine this.

*Your TLE and Organized Lubrication

Your Texaco Lubrication Engineer can offer you many helpful hints on the lubrication and maintenance of process equipment. He'll also be glad to help you plan toward Organized Lubrication as a means of raising production, controlling maintenance costs and downtime, and extending equipment life. Texaco Inc., 135 East 42nd Street, New York 17, N. Y.

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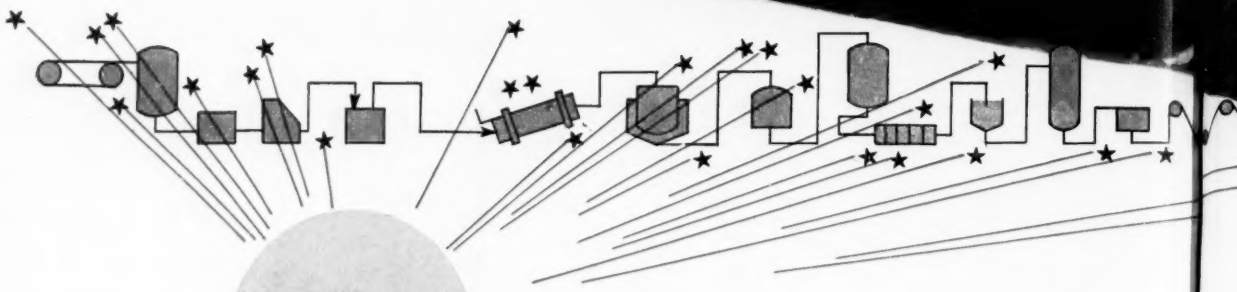
DEVELOPMENTS . . .

PROCESS FLOWSHEET



Instruments control almost 2,000 variables in new cellophane plant.

Controls Wrap Up Cellophane

Converting tall hemlock trees into a strong transparent film called cellophane is a miracle of chemistry and a long-time industrial art. Now cellophane making, like so many other branches of industrial chemistry, is becoming less of an art and more of a science. Case in point: American Viscose Corp.'s new 50-million-lb./yr. cellophane plant at Marcus Hook, Pa., where $3 million has been spent to introduce the modern elements of process control into the traditional cellophane flowsheet.

Despite the invasion of many new films into the packaging field, cellophane sales continue to grow at a handsome rate. With shipments surging over the 435-million-lb. mark in 1959, producers now foresee a 500-million-lb./yr. market within the next two years. In anticipation of this growing demand, all three producers (Avisco, Du Pont and Olin Mathieson) are hiking capacity to about 560 million lb./yr.

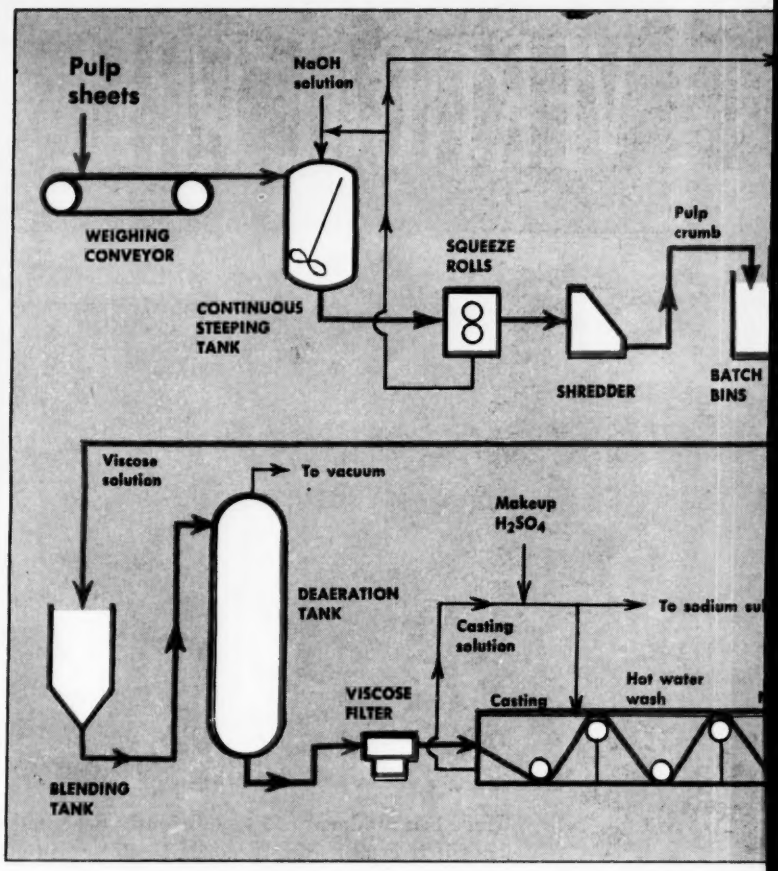
Avisco's other cellophane plant, rated at 100 million lb./yr., is located at Fredericksburg, Va., and employs practically the same process that went into the new Marcus Hook facility. The main difference is the heavy emphasis on instrumentation in the new plant to improve quality, reduce costs and boost productivity.

▶ **Digest With Caustic**—To start the process, sheets of dissolving pulp are placed on an automatic weighing conveyor which charges pulp to the mixing tank at a preset rate. Alpha-cellulose content of the pulp sheets is slightly over 90%; cellophane makers try to get as high alpha content as possible since only about half of the beta-cellulose and little of the gamma-cellulose ever shows up as cellophane. Yields average roughly one pound of raw cellophane per pound of pulp charged.

Pulp mixes with 20% caustic solution at 70 F. to break up the sheets. Pulp slurry from the

Unfold Flowsheet

R. A. LABINE



Manufacture

mixing tanks flows continuously through rolls which squeeze out most of the caustic. Pulp particles then feed via a vibrating conveyor to the shredding machine which reduces all lumps to about ½-in. size.

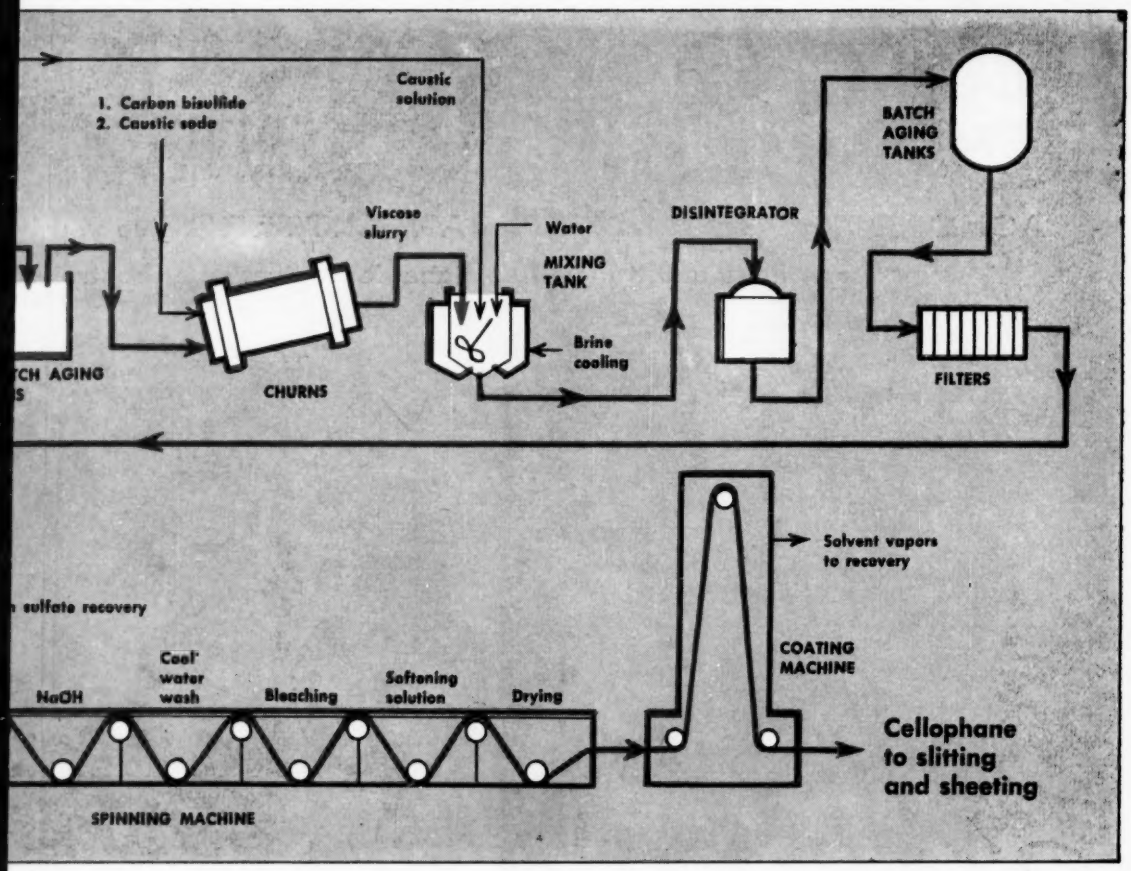
▸ **Age Carefully**—Pulp crumbs fall from the shredders into aging cans holding nearly 1 ton each. Crumbs are then stored for about 20 hr.

After aging, more than two tons of pulp crumb is charged to a cylindrical churn and carbon bisulfide is added while rotating blades assure intimate mixing. Pulp reacts to form orange-colored xanthate which is then suspended in solution by adding sodium hydroxide. Viscose slurry passes through a mixer to dissolve any unreacted lumps and after blending, flows down to the aging cellar to ripen for two days while xanthate undergoes partial hydrolysis. Viscose solution must be cast within narrow time limits of optimum viscosity (determined by a falling-ball test).

▸ **Process Variations**—At the older Fredericksburg plant, aging process carries on in individual batches, passing from the receiving tank through a filter to the aging tank, then through deaeration tanks to the spinning machine which forms cellophane web.

In the new Marcus Hook plant, viscose solution ages batchwise in the receiving tanks, then passes through filters to deaeration tanks where air bubbles are removed under vacuum. Viscose from the bottom of the deaerating tanks flows continuously to the spinning section.

▸ **Spinning Is Complex**—Viscose solution passes through a pancake filter into the spinning heads—slit dies 100 in. long. Contacting sulfuric acid-sodium sulfate bath at 105 F., viscose solution hardens into a solid sheet. Feeding through the rest of the machine, the sheet is successively washed with hot water, sodium hydroxide, cool water, ClO_2 bleach, more water, and finally ab-



rbs a glycerine softening agent. After drying, e raw cellophane sheet is wound in rolls. Each ll holds continuous web of cellophane five miles ng.

Last: Coating—Raw cellophane rolls feed the ating machine where application of various atings can make the sheet moisture-proof, heat aling and grease proof. Avisco makes more an 50 different kinds of cellophane by varying e kind and amount of wax, resin or polymer hich it applies to the raw cellophane base.

After being coated and dried, the cellophane rerolled and sent to the final slitting and sheet- g operations.

Enter Instrumentation—At the new Marcus ook plant, instruments make automatic correc- ons at 95% of the 2,000 control points in the rocess. For example, there are 60 variables un- r automatic control on each of the ten spin- ng machines. In the Fredericksburg plant, only 25% of the controls are automatic. The other variables are controlled by operators with subsequently wider process variations and longer correction time.

Data loggers in the spinning section at Marcus Hook monitor 500 points and can provide a complete readout in one minute. In actual operation, however, readings are taken only about every 15 min.

Although it is still too early to cite cost figures, Avisco figures this expensive instrument package will pay for itself by improving the product quality and reducing the 10% waste found in older plants. Labor savings don't figure prominently in Avisco's calculations: Marcus Hook employs about 650 workers compared to about 2,000 for the Fredericksburg plant which has double the capacity. Too, Marcus Hook needs more skilled and higher-paid men to tend the sophisticated instrumentation system.

DATA LOGGING unit in the new Marcus Hook plant can provide a readout of 500 spinning line variables in one minute.

SPINNING MACHINES each have 60 variables which are controlled automatically to provide tighter quality control.

How B&W JOB-MATCHED STAINLESS PIPE

saves time and money in corrosive service

At B&W, you can select the most economical stainless steel pipe for *your* service conditions, because...

...the right grade and size is available—seamless or welded.

...you get the stainless properties, in the right combination, to simplify bending, forming, and other fabrication operations.

...you benefit from B&W's long experience in matching pipe and tubing to process industry applications.

For more information on how you can order B&W Job-Matched Pipe—and B&W Job-Matched Fittings — all from one source, call the tubing specialist at your local B&W District Sales Office. Or write for Bulletin TB-410. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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signal

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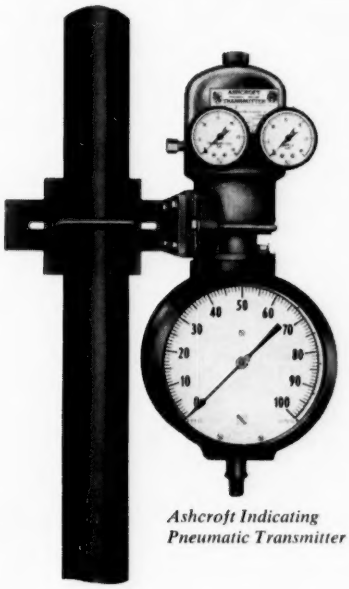

Ashcroft Indicating Pneumatic Transmitter

action

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters achieve these results for you at the lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters eliminate the need for costly high pressure lines, yet permit complete monitoring of process conditions in remote areas.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated systems for sensing pressure or temperature conditions. You also get a time-proven, obstruction-proof, force-balance, nonbleed relay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges for your specific requirements.

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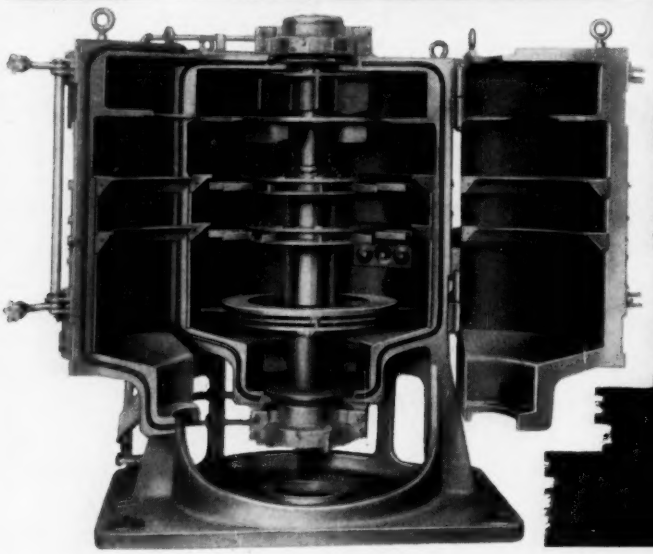

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Here is a modern mill so efficiently designed for its purpose that it is establishing records in the economical production of extremely fine materials in the sub-sieve particle sizes.

The prime features of the Raymond Vertical Mill are simplicity and accessibility. It permits quick set-ups to minimize down-time—easy cleaning and adjustments facilitate changes from one product to another—simplified control and automatic operation save production time.

This unit has wide application to a great variety of chemicals, pigments, synthetic resins, phosphate materials and many special products. It is serving modern industry in making solid rocket propellants, and it does an excellent job in pulverizing ammonium nitrate and ammonium perchlorate oxidizers.

The Vertical Mill gives good results in grinding non-abrasive materials to high fineness ranging from minus 325 mesh into the sub-sieve sizes. On some softer materials, reductions to 95% to 98% finer than 5 to 10 microns are readily obtainable with this mill. *If you have a hi-fineness grinding problem, write us for detailed information.*

Raymond Bulletin No. 78 gives full details of superfine grinding operations. Write for your copy.

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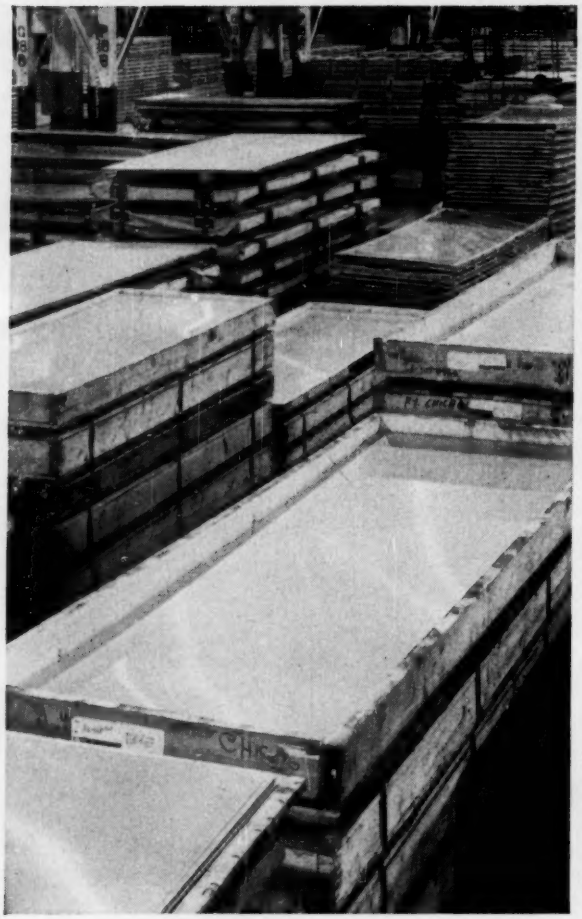
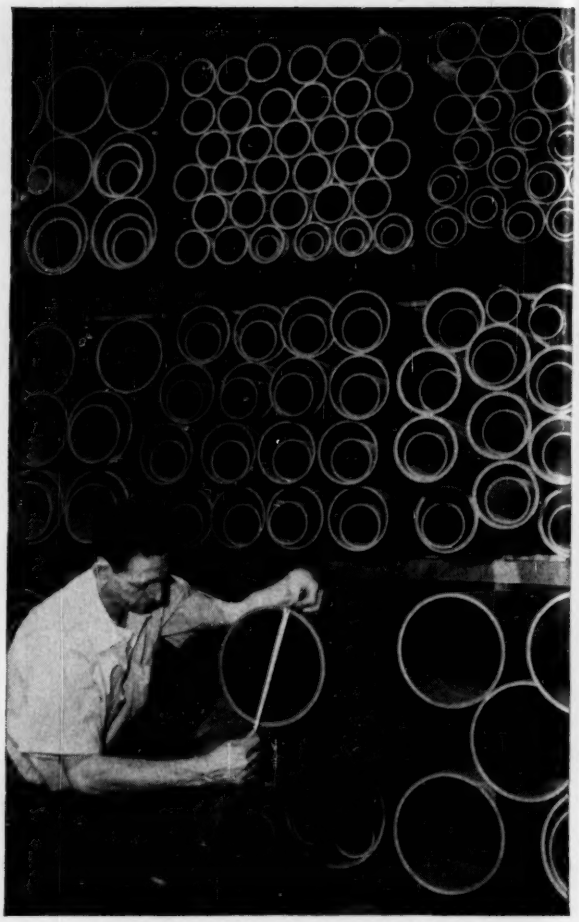
Typical Coppus Blue Ribbon features are: *totally enclosed governor . . . totally enclosed and independently operated safety trip . . . easily replaceable packing and bearings . . . multiple steam nozzle control . . . brake rim for added safety . . . wide bucket "L" type wheel (optional) for minimum water rate.* You get higher efficiency operation . . . less down time . . . lower maintenance costs.

Coppus Turbines are built to customers' specifications, including API and NEMA standards. Send for Catalog 200. Get complete details on Coppus Turbines. Sizes from 1 HP to 250 HP. Write COPPUS ENGINEERING CORPORATION, 223 Park Avenue, Worcester, Mass. Sales Offices in *Thomas' Register*.

COPPUS
STEAM TURBINES





Stainless . . . or Plastic

WHICH ONE SOLVES YOUR CORROSION PROBLEMS BEST?

Ryerson offers both these corrosion fighters

Where high pressure and high temperatures demand *high-strength steel*, stainless is the overwhelming choice. And when you need stainless, look to Ryerson—with 2351 kinds and sizes of sheets, plates, bars, tubing, pipe and fittings in stock. In addition, our cutting equipment is unexcelled. For example, we can cut plates up to 12′ x 25′ absolutely square on our abrasive disc saw and accurately flame-cut intricate shapes.

On many other applications the best answer to your corrosion problem may be plastic, Ryertex®-Omicron PVC (polyvinyl chloride). Exclusive from Ryerson, this lightweight, rigid plastic licks more than 280 corrosive liquids and gases. It has been successfully used, when properly installed, at operating temperatures up to 212° F. Chemically inert, PVC imparts no odors or tastes; resists weathering, rotting and "aging." Non-sparking and nonmagnetic. Offered in pipe and fittings, sheets, rods, and fabricated parts.

A Ryerson specialist will gladly give you all the facts about both these anticorrosive materials—and about Ryerson's immediate service that meets your exact requirements. Call your nearby Ryerson plant today.

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RYERSON PLUS VALUES

INDUSTRIAL PLASTICS AND BEARINGS DIVISION

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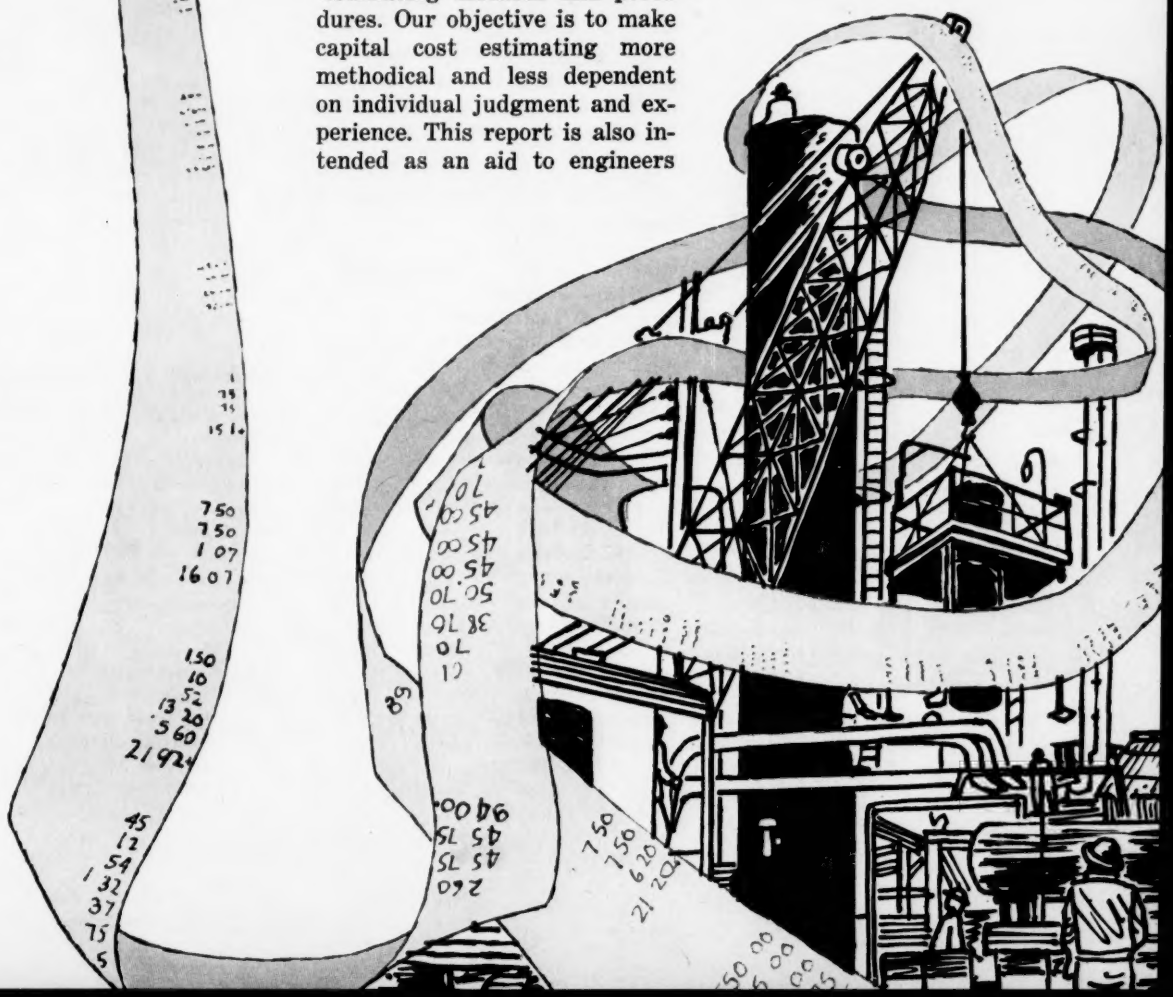
Chemical Engineering
MARCH 7, 1960

Capital Cost Estimates For Process Industries

JOHN W. HACKNEY, Beaco, Ltd., Montreal, Que.

COST estimating for process industries is in the state of transition between art and science. This two-part report is an attempt to collect and integrate established and newly developed estimating methods and procedures. Our objective is to make capital cost estimating more methodical and less dependent on individual judgment and experience. This report is also intended as an aid to engineers who occasionally must make capital cost estimates for process plants but who cannot devote a great deal of time to the review and analysis of current estimating literature.



In general, estimating is based on:

- Definition of cost elements so that cost records and estimates have a common basis.
- Collection of cost records based on these definitions.
- Classification and grouping of cost records.
- Analysis of the relationships among cost records.
- Utilization of procedures based on these relationships, and the collected and classified cost record to make cost estimates.

Emphasis in this report is on definitions and procedures. When uniform definitions and procedures can be used, every project record contributes to the common store of estimating data. Hence, every engineer can confidently utilize these data in making his own estimates.

Part I of this report covers the more or less independent procedures for estimating individual portions of project costs. The procedures are:

1. General procedures.
2. Equipment estimating.
3. Material estimating.
4. Labor estimating.
5. Design and field expense.

These procedures can be combined for use in making estimates by one of several different methods. Each method is a co-ordinate grouping of appropriate procedures. Four such methods will be discussed in Part II which will appear in an upcoming issue of *Chem. Eng.*

Also, Part II will include contingencies and appraisal of estimating methods, with a discussion of project information required, time required for estimating and relative accuracy of each method.

This report discusses basic estimating procedures and their application, but does not provide the data necessary for the preparation of a cost estimate.

Provide Adequate Estimating Data

Considerable data must be available and organized before estimating procedures become useful to the cost estimator. Preparatory work for cost estimates includes organization of estimating data, methods of adjusting cost records to current prices, methods of adjusting costs of complete process units for capacity and developing land and site-clearing costs.

Organizing Cost Data

Cost estimates for a modern process plant involve so many features that it is absolutely essential to have some means by which the vast welter of detail can be organized. Costs of past projects must be collected and identified. These costs must be stored in the department records, and they must be easily available from storage for use in making new estimates.

Availability of these data requires a standardized numerical system of classifying cost data. Such a standardized system is indispensable if field accountants, estimators and designers are to have a common basis of understanding for allocation of project costs.

In establishing this account subdivision system the following objectives were considered.

- Account list for a cost estimate should present a logical picture of the scope of the project, with major operating divisions identified and listed in operating sequence.
- Individual account subdivisions should be work units which can be easily segregated and identified in the field.
- Standard accounts should be complete enough to reduce the possibility of overlooking any major element of cost in the estimate.
- Account system should be suitable for use with tabulating machines so as to reduce the cost of obtaining information on the larger projects.
- The system should be as simple as possible, consistent with the great number of units to be classified and the many purposes which must be served.

An account subdivision system must also satisfy requirements with respect to its use for property accounting and for construction planning and control.

Cost estimates should be broken down into primary divisions, each consisting of a major element of operation. These primary divisions state the purpose to be accomplished by the installations in that division and not the method or type of equipment to be used. Where possible, the divisions should coincide with operating departments or sub-departments. They should be listed as nearly as possible in operating sequence. When distribution systems, collection systems, utilities or buildings serve more than one division, they should be listed in a separate division.

As an example, an estimate for chlorine capacity increase might have the following primary divisions.

- Salt unloading.
- D.C. power conversion.
- Chlorine storage.

Work in each primary division should be broken down into construction account subdivisions in

Account Subdivision List

Preparatory	01 to 09
Structures	11 to 19
Storage	21 to 29
Piping and duct work	31 to 39
Equipment	41 to 49
Equipment	51 to 59
Electrical	61 to 69
Site improvements	71 to 79
Engineering expense	
Field	81 to 86
Design	87 to 89
Construction expense	
Procurement	91
Equipment, tools, supplies	92
Temporary facilities	93
Services	94
Administration, fees	95

accordance with the work descriptions given in the table below.

Each subdivision is assigned a four-digit number. The first two digits from the left are from the account subdivision list. The first digit classifies the work as to general type of construction involved, such as structures, piping, electrical.

The second digit classifies the type of construction work. For example, if the first digit is 6, the work is of an electrical nature. If the first digit is 6 and the second digit is 1, the work involved is lighting (61-).

A third digit gives the number of the primary division, and indicates the operating division of which this work is a part. It is separated by a dash from the second digit.

The fourth digit is a zero except when there is more than one item of a like classification in a primary division as shown by 31-30 and 31-31 in the table. Where the project is made up of more than ten primary divisions, ranges are assigned to primary divisions such as −10 to −14 might cover chlorine supply.

Adjust Costs to Current Price

Construction cost estimates based on records of former projects must be corrected to the current value of the dollar. This correction is usually substantial, since construction prices have doubled in the 13 years between 1947 and 1960.

Many indexes are available which purport to measure the change in value of the construction dollar. The most widely used in process industries are:

Marshall & Stevens (Published in *Chemical Engineering*).

Nelson Refinery Index (Published in *Oil and Gas Journal*).

Engineering News-Record Construction Index.

A comparison of these indexes was made by W. R. Nelson in his "Cost-imating Article 61," in the *Oil and Gas J.* for Dec. 15, 1949. The comparison was inconclusive. Another study comparing the merits of 16 of the available indexes came to the conclusion that for process plant estimating purposes there was little basis for a choice among them.

Based on length of publication record and promptness of availability, the *Engineering News-Record* Construction Index is one of the best, and has been used for these studies. A standard value of 600 has been adopted, although almost any other value, including the 1913 base index of 100, would be as good. Using 100 as a base would in some cases reduce the indexing procedure by one arithmetic operation. However, the 600 base, at least for the near future, prevents cataclysmic errors when indexing is overlooked.

Two examples indicate the general method of using cost indexes: Find the cost in July 1958 of a filter wheel similar to one purchased in May 1946.

Filter wheel cost, May 1946	$19,204
ENR Index, May 1946	340
ENR Index, July 1958	760
Cost of similar filter, July 1958 $19,200 × 760/340	$43,000

Find the cost in July 1958 of filter wheel with 600 sq. ft. of filter area.

From capacity-cost curve, based on ENR 400, filter cost	$21,000
ENR Construction Index, July 1958	760
Cost of filter, July 1958 $21,000 × 760/400	$40,000

Although the *Engineering News-Record* Construction Index measures the change in value of the construction dollar, fluctuation of prices of individual pieces of equipment, buildings, roads, railroads, pipelines and other major items of construction will vary in a somewhat different manner. There are special indexes available to measure the fluctuations of many of these items.

In general, the increase in accuracy obtained by using individual indexes for each item of a cost estimate is outweighed by the resulting unwieldy complexity. In cases where the greater part of the estimate is dominated by a single item, a power generator for example, the accuracy of the estimate can be improved by using the special index for such an

Arrange by Primary Divisions

Salt Unloading —10
- 03-10 Remove two wood-stave tanks
- 13-10 Conveyor foundations
- 16-10 Conveyor supporting frame
- 57-10 Belt conveyor, 2 x 217 ft. with motor and drive
- 61-10 Unloading area lighting
- 66-10 Power supply to conveyor

D. C. Power Conversion —20
- 63-20 Install new arc limiters on five rectifiers
- 66-20 Power supply for arc limiters on five rectifiers

Chlorine Storage —30
- 03-30 Remove scrap from storage tank area
- 13-30 Chlorine storage tank foundations
- 21-30 New chlorine storage tank, 55 tons
- 31-30 Liquid chlorine piping for storage tank
- 31-31 Snift-gas piping for storage tank

Rearrange by Construction Account

Preparatory
- 03-10 Remove two wood-stave tanks
- 03-30 Remove scrap from storage tank area

Structures
- 13-10 Conveyor foundations
- 13-30 Chlorine storage tank foundations
- 16-10 Conveyor supporting frame

Storage
- 21-30 New chlorine storage tank, 55 tons

Piping
- 31-30 Liquid chlorine piping from storage tank
- 31-31 Snift-gas piping from storage tank

Process Equipment
- 57-10 Belt conveyor, 2 x 217 ft. with motor and drive

Electrical Equipment
- 61-10 Unloading area lighting
- 63-20 Install new arc limiters on five rectifiers
- 66-10 Power supply to conveyor
- 66-20 Power supply for arc limiters on five rectifiers

Construction Cost Index

1960*	813.2
1959	797.4
1958	759.2
1957	723.9
1956	692.4
1955	659.7
1954	628.0
1953	600.0
1952	569.4
1951	542.7
1950	509.6
1949	477.0
1948	460.7
1947	413.2

*Annual averages, except for 1960 as of Jan. 21, 1960, from *Engineering-News Record*.

item. In most cases, a more accurate and almost equally prompt preliminary cost estimate can be obtained from a vendor.

Cost of Process Units

For complete process plant units, making identical products by identical processes with identical site conditions, the following relation gives costs of similar plants at different capacities:

$$\frac{\text{Cost of unit A}}{\text{Cost of unit B}} = \left(\frac{\text{Capacity of unit A}}{\text{Capacity of unit B}}\right)^{y}.$$

where y is the process unit capacity-cost exponent whose value is less than one. The value of y approaches closer to one when unit capacity is increased by adding identical production lines instead of by increasing the size of process equipment.

A process plant unit is defined as a complete installation capable of performing a unit process. It does not include the utilities, raw material supply, service buildings, product shipping yard improvements and other service facilities required to transform a group of process units into an operating plant.

The table* on this page gives capacity-cost exponents for various process units.

An example showing application of the method follows:

Assume recorded cost of a soybean plant, built in 1949 with a capacity of 100 tons/day as $600,000. Find the cost of a similar 300 ton/day plant in July 1958.

ENR Construction Index for 1949 477

ENR Construction Index for July 1958 760

Cost of 100 ton/day plant in July 1958
$600,000 × 760/477 ..... $950,000

Capacity ratio: 300/100 ..... 3.0

Cost ratio: $(3.0)^{0.7}$ 2.16

Estimated cost, 300 ton/day plant in July 1958
$950,000 × 2.16 ..... $2,100,000

An attempt to check this capacity-cost relationship for four jobs of record yielded only fair results. These were four very similar production units, one put in as a complete new plant, one as an addition with raw material and product storage, one as an addition with product storage and one as an addition with no storage. All units were housed in new buildings. They were built over a 6-yr. period.

Considering the total project costs, there was little trace of exponential relationship between the projects. If the exponential method with ENR index correction had been used for estimating the cost of only the process units common to the four plants, estimating errors would be as follows assuming exponent y is 0.7:

	Estimating Errors for Plant		
Basis of Estimate	B	C	D
Plant A	4%	41%	31%
Plant B	...	23%	8%
Plant C	...	....	−19%

*Data obtained from W. L. Nelson, *Oil & Gas. J.*, Oct. 5, 1950.

Process Unit Capacity-Cost Exponents

$$\frac{\text{Cost of unit A}}{\text{Cost of unit B}} = \left(\frac{\text{Capacity of unit A}}{\text{Capacity of unit B}}\right)^{y}$$

	y
Refrigeration plants includes auxiliaries[8]	0.85–0.96
Refrigeration plants no auxiliaries[8]	0.80–0.82
Complete refinery, catalytic cracking[1]	0.85
Coke-oven gas separation[2]	0.82
Water-gas plant[2]	0.81
Water-treating plant[3]	0.91
Vacuum distillation[4]	0.80
Catalytic cracking only[1]	0.78
Solvent dewaxing[5]	0.76
CO and CO_2 removal from hydrogen[2]	0.74
Peterson sulfuric acid towers[2]	0.73
Coking only[1]	0.72
Catalytic polymerization[1]	0.70
Soybean extraction[3]	0.70
Water-gas shift conversion[2]	0.69
Contact sulfuric acid[2, 6]	0.64–0.66
Solvent extraction or treating[5]	0.67
Vacuum flash[4]	0.64
Chamber sulfuric acid[6]	0.60
Oxygen plant[3]	0.59
Natural gasoline plants[5]	0.51
Thermal cracking only[5]	0.51
Small oxygen plant[2]	0.47
Hypersorption[5]	0.43

1. Nelson, W. L., "Over-all Plant Costs—Cracking," *Oil & Gas J.*, Nov. 24, 1949, p. 149
2. Sherwood, P. W., "Effect of Plant Process Size on Capital Costs," *Oil & Gas J.*, Mar. 9, 1950, p. 81.
3. Chilton, C. H., "Cost Data Correlated," *Chem. Eng.* June 1949 p. 49.
4. Nelson, W. L. "Cost of Vacuum Plants," *Oil & Gas, J.*, Sept. 18, 1950.
5. Nelson, W. L., "Over-all Plant Costs—Distillation, etc.," *Oil & Gas J.*, Dec. 1, 1949, p. 93.
6. Barr, J. A., "H_2SO_4 Buy or Build," *Chem. Eng.* Apr. 1950, p. 106.
7. "Platforming Process," *Oil & Gas. J.*, Apr. 6, 1950, p. 89.
8. Nelson, W. L., "Refrigeration Plants," *Oil & Gas J.*, July 7, 1949, p. 95.
9. Nelson, W. L., "Cost versus Size," *Oil & Gas J.*, Oct. 5, 1959, p. 263.
10. Williams, Jr., R., "0.6 Factor Aids in Approximating Costs," *Chem. Eng.*, Dec. 1947.
11. Chilton, C. H., "0.6 Factor Applies to Complete Plant Costs," *Chem. Eng.*, Apr. 1950.
12. Nelson, W. L., "What Price Complete Refinery Installations," *Oil & Gas J.*, Nov. 23, 1953.

Reasons for these discrepancies were many and varied. Local wage rate differences accounted for some. Foundation conditions differed. Technical changes were made in furnace design. Construction supervision and contract arrangements varied. Materials of building construction were not the same. Also the ENR index is not a perfect indicator of price changes. All of these combined to produce the variations shown.

A more legitimate use of this estimating procedure is to approximate the costs of homologous process units at various capacities when the cost at a single capacity has been carefully estimated by other methods.

Assume the capacity-cost exponent to be 0.70. If the estimated cost of the 300 ton/day unit is $1,600,000, then the cost at other capacities may be approximated as shown in the following table.

A Capacity Tons/Day	B Capacity Ratio A/300	C Cost Ratio B×0.70	D Estimated Cost of Unit $1,600,000×C
100	0.333	0.463	742,000
200	0.667	0.752	1,206,000
300	1.000	1.000	1,600,000
400	1.333	1.223	1,960,000

The exponential relationship between capacity and cost has some general validity, but cannot be relied upon for estimates of a high degree of accuracy.

Estimating Land Costs

Estimates of land cost usually have a low accuracy. Fortunately land cost is a small part of total project cost and usually it is a matter of record before the engineering has advanced to a point where accurate estimates must be made.

Site clearing costs are also difficult to determine with any degree of accuracy, especially in the early stages of a project. Even for a preliminary estimate, the estimator should make every effort to visit the plant site personally. During this visit, he should carefully observe and note every obstacle to the construction of the plant. The cost of removing obstructions which often includes putting service lines in some other location can run into a considerable sum of money.

Some of this work may be estimated by picturing the size of crew and amount of time required to do the work. In other cases, site clearing can be estimated by conventional detailed methods.

Equipment Estimating Procedures

Sources of equipment prices, methods of adjusting equipment prices for capacity and methods of estimating auxiliary process equipment are essential to the estimator in making reliable costs estimates.

Equipment Prices

The most accurate method of determining process equipment values is to obtain firm bids from fabricators and suppliers. Often, vendors can supply quick estimating figures which will be very close to bid prices but not involve much of the vendor's time.

Second best in reliability are values from the file of past purchase orders. These prices are indexed for rapid finding in accordance with the standard account subdivision system. When used for pricing new equipment, purchase order prices must be corrected to the current cost index.

Published Sources

Much information has been published on detailed equipment cost estimating. The following have been found to be especially useful:

1. "Chemical Engineering Costs," O. T. Zimmerman and I. Lavine, Industrial Research Service, Dover, N. H.

2. "Cost-imating," W. L. Nelson, *Oil & Gas J.*

3. "Cost File," *Chem. Eng.*

Other sources, such as Chilton's "Cost Data Correlated," *Chem. Eng.*, June 1949; and Aries and Newton's "Chemical Engineering Cost Estimation," Chemonomics, Inc.; give log-log plots of capacity versus installed cost of various types of process equipment. These are difficult to use because installation costs are quite variable and the amount of installation cost included in these graphs is not known.

Capacity vs. Cost

For common types of process equipment such as tanks and heat-exchangers, the information contained in the purchase order file can be summarized on charts of capacity versus cost, corrected to a standard construction cost index of 600. On log-log plotting paper, process equipment cost data often show straight line characteristics which indicate an exponential relationship between capacity and cost.

Capacity and cost of homologous items of equipment are often related in the form:

$$\left(\frac{\text{Cost of A}}{\text{Cost of B}}\right) = \left(\frac{\text{Capacity of A}}{\text{Capacity of B}}\right)^x$$

Here x is the capacity-cost exponent, usually less than one. For equipment in general, an average capacity-cost exponent of six-tenths is suggested by Nelson.*

The following examples illustrate the use of capacity-cost exponents. One example shows how to use the capacity-cost exponent to estimate equipment cost at current prices if capacity and cost are known at some other capacity. The other shows how to apply the ENR cost index to capacity-cost relations.

Find the cost of a 40,000 bbl. cone-roof tank. A recent bid price for a 20,000-bbl. cone-roof tank was $35,000.

Capacity ratio: 40,000/20,000 = 2.0.

Capacity-cost exponent: 0.6 (assumed).

Cost ratio: $(2.0)^{0.6} = 1.565$.

Estimated cost of 40,000 bbl. tank: $35,000 × 1.565 = $55,000.

Find the cost in July 1953 of a 3,500 lb./hr. steam boiler. A comparable boiler, having a capacity of 5,500 lb./hr. cost $10,560 in July 1946.

ENR construction cost index for July 1953 was 604 while for July 1946 was 354.

Hence, cost of 5,500 lb./hr. boiler in July 1953 becomes: (604/354) × $10,560 = $18,000.

Capacity ratio: 3,500/5,500 = 0.636.

Capacity cost exponent = 0.6 (assumed).

Cost ratio: $(0.636)^{0.6} = 0.762$.

Estimated cost in July 1953 of 3,500 lb./hr. steam boiler is 0.762 × $18,000 or $13,700.

* For typical capacity-cost exponents of process equipment, see W. L. Nelson, "Cost-imating Series," *Oil & Gas J.*, Oct. 5, 1950, p. 263.

Estimate Auxiliary Process Units

In the early stages of a project's development, major items of process equipment are often well established as to type, number, size and materials of construction. This major process equipment can be readily priced by methods previously discussed.

However, there is considerable auxiliary process equipment which cannot be sized or priced without a great deal of additional engineering work. If the process equipment required for a plant is divided into two well-defined classifications, then projects of record can be analyzed to determine cost ratios which have existed in the past between the two classifications. The classifications are: major process equipment and auxiliary process equipment.

Knowing the value of the major process equipment for a new project, and the probable auxiliary process equipment ratio, we can determine the approximate cost of auxiliary process equipment without expending the time required for detailed engineering and pricing of the auxiliary equipment.

To use this ratio method successfully, strict definition of the component parts is essential. Recommended definitions are given in the accompanying table.

Define Process Equipment Carefully

Major Process Equipment E_m

Equipment in which process material undergoes a change of state, condition or composition; or equipment in which process material is stored.

Does include major process equipment complete with drives, agitators, heaters and all factory attached or supplied equipment elements.

Examples:

- Bag packers
- Circulating pumps
- Container fabricating equipment
- Furnaces, complete with brick
- Installed spare major process equipment
- Rectifiers and transformers
- Silos and storage tanks
- Water treatment equipment

Does not include, except when they are an integral, factory-assembled or supplied part of a major process equipment unit.

Examples:

- Chutes and conveyors
- Electrical control, instruments
- Insulation and piping
- Transfer pumps
- Vibrating feeders

Auxiliary Process Equipment E_a

Equipment associated with major process equipment for material movement, instrumentation, process control and electrical control.

For example: does include when in process service

- Blowers
- Control valves
- Conveyors, elevators
- Instruments and controls
- Motor control centers
- Over-head cranes
- Pumps, vibrating feeders
- Weighing devices

Does not include:

- Air or gas ducts
- Piping
- Wiring
- Insulation
- Power distribution substations
- Piping and wiring for instruments

Process Equipment E_p

$E_p = E_m + E_a$

Auxiliary Equipment Ratio

If we have a tabulation of auxiliary process equipment ratios ($e_a = E_a/E_m$) for similar projects, we can obtain an estimate of the value of the auxiliary process equipment. Multiplying the value of the major process equipment which is determined early in the project by the probable auxiliary equipment ratio gives an estimate of the value of the auxiliary process equipment.

Total range of e_a is from 0.00 to about 2.00 with usual values in the range of 0.25 to 0.60. The breadth of these ranges indicates the necessity for selecting the ratios with great care. Tabulation of ratios of auxiliary process equipment to major process equipment for past projects is essential.

Moreover, use of ratios for computing the value of auxiliary process equipment can never be as accurate as detailed design, take-off and pricing of this equipment. As the design of a project advances and the possibility of a more accurate estimate develops, this auxiliary equipment should be listed and priced by the means described for major process equipment.

Freight Costs

Freight cost for equipment, except for remote locations, is a relatively minor item. Average freight for equipment for a chemical plant ranges from less than 1% to about 2% of the equipment cost.

Rates for important shipments should be computed by the company's traffic department. If such help is not available, the railroad serving the plant can provide an estimate of the probable cost of freight.

How to Estimate Other Material

Having discussed the estimating of major and auxiliary process equipment, we can turn our attention to the problem of making preliminary estimates of the additional material which is required to make the process equipment operable. This includes not only material directly associated with the process equipment, but also the material required for site improvement, utilities and other service facilities of a plant.

Equipment ratio method of estimating this material is based on the general observation that the material cost of a process plant tends to be directly proportional to the value of its process equipment.

For detailed analysis of this relationship, the total equipment and material cost of a plant can be broken down into the groups shown in the table. Capital letters with subscripts indicate dollar values while small letters with corresponding subscripts indicate ratios of the dollar value of the item to the dollar value of the process equipment. Since these ratios are typical for similar processes, they can be used to make preliminary estimates of material cost.

Usually the size, type and value of major process equipment can be determined early in the development of the project. Value of auxiliary

Define and Specify Material Groups for Use With Equipment Ratios

Process Equipment Material M_e, $M_e = M_i + M_p + M_w$

Equipment foundations, insulation, supports, paint

For example:
- Equipment foundations, insulation, supports, paint
- Instrument cases, panel boards
- Piping, wiring for process instruments and controls
- Platforms, stairs and walkways

Does not include
- Building grade slabs or stairways
- Pipe insulation, power wiring, process piping

Process Piping Material M_p

For example:
- Air and gas ducts
- Pipe, fittings, hangers, insulation and supports
- Process sewers and stacks
- Valves except power-actuated control valves

Does not include
- Piping and duct work outside process unit area (M_d)
- Sanitary plumbing (M_{sb}) or storm sewers (M_{ys})
- Piping and wiring for instruments and controls (M_i)

Process Wiring Material M_w

For example:
- Bus bars, clamps, duct and wire
- Cable, conduit and fittings, insulators

Does not include
- Instruments, controls or motor control centers (E_a)
- Electrical equipment outside process unit area (M_d)
- Lighting or building service wiring (M_b)

Total Building Material M_b, $M_b = M_{pb} + M_{sb}$

Process Building Material M_{pb}

For example:
- Air conditioning, heating, lighting, ventilation
- Building space for process units
- Building space for in-process storage
- Process control rooms, pump houses

Does not include
- Space in process building for offices, maintenance, warehousing, lockers, change rooms
- Plumbing, heating or lighting for service spaces
- Utilities or yard improvements serving process buildings

Service Building Material and Equipment M_{sb}

For example:
- Air conditioning, heating, plumbing, ventilation
- First aid equipment, lockers, partitions
- Lighting, overhead cranes, sprinklers
- Shop and storeroom equipment
- Buildings for cafeterias, garages, offices, toolrooms and warehouses

Does not include
- Pump houses, building space for in-process storage
- Utilities and sewers serving the buildings

Distribution Material M_d

Includes all materials and equipment required to distribute to or from process units.

For example:
- Electrical power M_{de}
- Steam M_{ds}
- Water M_{dw}
- Raw materials and finishes products M_{dp}
- Fuel, air, refrigeration M_{do}
- Pipe bridges M_{db}
- Buildings or space for utility control rooms
- Product lines to customers
- Tank cars and barges

Does not include
- Items considered to be process equipment such as:
- Electrical generators, rectifiers, refrigeration equipment
- Sewage and water treatment equipment
- Sewers (M_y)
- Material distribution in process unit area

Yard Improvement Material M_y

For example:
- Railroads M_{yt}
- Roads, area paving, sidewalks M_{yr}
- Grading, fencing, planting, lighting M_{ym}
- Sewers M_{ys}
- Waterfront structures and other yard improvements M_{yo}

Total Plant Material M_t

$M_t = M_e + M_b + M_d + M_y$

Includes all material for the complete plant except process equipment E_p

Typical Ranges of Material Ratios

Process Equipment Material Ratios		
Equipment installation	$m_i = M_i/E_p$	0.178–0.281
Piping	$m_p = M_p/E_p$	0.083–0.177
Wiring	$m_w = M_w/E_p$	0.032–0.080
Total process equipment	$m_e = M_e/E_p$	0.322–0.535
Building Material Ratios		
Process building	$m_{pb} = M_{pb}/E_p$	0.253–0.326
Service Building	$m_{sb} = M_{sb}/E_p$	0.040
Total building material	$m_b = M_b/E_p$	0.293–0.366
Distribution Material		
Electrical power	$m_{de} = M_{de}/E_p$	0.085
Steam distribution	$m_{ds} = M_{ds}/E_p$	0.025
Water distribution	$m_{dw} = M_{dw}/E_p$	0.041
Raw material and product	$m_{dp} = M_{dp}/E_p$	.....
Pipe bridge	$m_{db} = M_{db}/E_p$	0.014
Other	$m_{do} = M_{do}/E_p$	.....
Total distribution material	$m_d = M_d/E_p$	0.165
Yard Material		
Trackage material	$m_{yt} = M_{yt}/E_p$	0.013
Road, parking, surfacing	$m_{yr} = M_{yr}/E_p$	0.017
Sewer	$m_{ys} = M_{ys}/E_p$	0.020
Fence, lighting, grading	$m_{ym} = M_{ym}/E_p$	0.006
Other yard material	$m_{yo} = M_{yo}/E_p$	.....
Total yard material	$m_y = M_y/E_p$	0.056
Total plant material (exclusive of process equipment)	$m_t = M_t/E_p$	0.836–1.122

process equipment can be determined by ratio. Adding auxiliary process equipment E_a to major process equipment E_m, we get the value of the process equipment E_p.

Equipment ratios for each of the material groups can be selected from a similar job-of-record. Applied to the value of process equipment for the new project, they will provide an approximation of the cost of materials for the new project. Since each material group can be considered separately, considerable judgment can be exercised in selecting, omitting and combining the equipment ratios to include all features of the new project.

Early material estimates may be entirely on an equipment ratio basis, but as the engineering design advances additional information becomes available. Hence, some material groups may be estimated by more exact methods. However, the more exact figures should be reviewed if they depart too widely from the equipment ratio figures.

When computing or using equipment ratios, the current market value of new process equipment rather than the book value must be used. For example, the same amount of foundation concrete must be bought whether the process equipment is purchased new from the factory at current prices, transferred from some other project or purchased second-hand at a low price. When entering the cost of process equipment in the final estimate, the actual book cost of the item is used. For a general picture of the relative magnitude of equipment ratios, see the table on this page. Projects included in this tabulation were of many types. Hence, the range of values is wide.

Selecting Ratios

Extreme care is necessary in selecting records to be used as sources so that installations selected are comparable to the new project.

Basic guide in selecting equipment ratios is a complete tabulation of experience-ratios for all company jobs-of-record. Published information can sometimes be worked into such tables, but the results are usually of doubtful validity because of variations in accounting practices.

Even within a company, estimated costs and recorded costs must be based on identical accounting practices and procedures if satisfactory results are to be obtained. For example: equipment rental can be listed as labor or material. Ratios computed either way are valid. However, if the estimate is made on one basis from costs recorded on another basis, there will be trouble.

Get Unit Material Prices

Unit material pricing for buildings, utilities and yard improvements are often subject to analysis in terms of their material cost per unit of size or capacity. Unit prices can be obtained for items such as buildings, pipelines, sewers, wells, electrical light and power.

Material cost tabulations are also necessary for site improvements such as cost per unit size for finished grading, roads, parking lots, railroad tracks, fences and docks.

All of these unit costs are tabulated for material only. Because of the extreme variations in labor cost per man-hour and variations in job conditions, it is necessary to compute labor on a man-hour basis.

Use Appropriation Ledger

With the aid of the appropriation ledger, the material for a completely engineered project can be priced in detail at little expense beyond that which is required for other engineering, procurement and accounting purposes.

The appropriation ledger serves several purposes other than the collection and organization of material cost information.

1. It is a means of finding requisition number, purchase order number and vendor when the general type and use of the material is known.

2. Each subdivision sheet can be checked to see that the material listed on it is adequate to complete the work.

3. Promised delivery can be compared to delivery required by the construction schedule and corrective measures taken if necessary.

4. Prints of appropriation record sheets can be included in final design report as a permanent reference record of material.

How to Estimate Labor Costs

Construction projects to be estimated for an industrial corporation take place under a bewildering variety of conditions. One project may be built in Cleveland by a lump sum contractor who is tops in the business and bidding tight to get the work. A second job may be handled by an inexperienced but hard-working Arkansas contractor. A third job may be in New Jersey with the work to be performed by local plant personnel.

Considering the wide range of possible project conditions, the estimator has little chance of successfully estimating by means of fixed unit prices. Consider two identical wall sections, fifty dollars will buy more or less concrete, depending not only upon the wage rates for the area but also upon the effectiveness of the workmen. This effectiveness is determined by job conditions.

Examine Labor Effectiveness

A complete list of conditions which influence construction-labor effectiveness would be very long. However, the checklist in the table gives the dominant job conditions that may be encountered.

Unfortunately, these job conditions are intangibles and hard to describe. It is difficult to determine quantitatively the change in man-hours caused by a change in one certain job condition.

To attack the problem, we will consider individually each of these dominant job conditions. We will discuss, in a general way, its effect on labor efficiency and try to develop the range of percentage increase which may be experienced as this job condition varies from perfection through good and poor to bad.

Here, the estimator's judgment must be relied upon to assign values in a particular case. This throws a heavy burden on the estimator and assumes a wide background of field experience. It does provide a check list of items to be considered and should aid to focus attention on each. The sum of these individual decisions will provide a reasonably good approximation of the total effect of probable job conditions.

Field Supervision

First on the list of job conditions and first in importance is supervision. Supervisors must not only be competent but also available in sufficient force to plan the work and to dissolve field difficulties as these arise. The number of supervisors required for adequate coverage depends to some extent on the other job conditions. Supervisors must be available in sufficient numbers to give the difficult portions of the job special attention while carrying on efficiently with routine work.

Proper numerical ratios between supervisors and workmen will vary from about one to four up to one to fifteen. In stating these ratios, we are including foremen but not pushers as construction supervisors. We define pushers as any supervisors who work with their hands more than half of the time.

A common ratio for new construction work of ordinary difficulty is one to eight. Higher worker ratios reduce output unless the work from day to day is of an un-

Checklist Gives Range of Job Condition Factors

	Expected Condition	Relative Man-Hour Increase Range	Project
Field supervision			
Number of supervisors		0–0.14	
Competence		0–0.14	
Organization, leadership		0–0.14	
Field labor			
Competence		0–0.35	
Attiude		0–0.35	
Type of contract		0–0.10	
Construction equipment and tools			
Major equipment		0–0.40	
Tools and minor equipment		0–0.35	
Maintenance		0–0.20	
Construction facilities and services			
Storerooms and yards		0–0.05	
Shops and offices		0–0.05	
Personnel facilities		0–0.05	
Temporary utilities		0–0.05	
Physical working conditions			
Weather		0–0.25	
Mud, dust, altitude		0–0.15	
Fumes, heat, hazards		0–0.40	
Access to work			
Roads		0–0.10	
Height		0–0.40	
Other		?	
Construction program			
Buildup rate		0–0.10	
Area loading		0–0.10	
Interruptions		0–0.15	
Material coordination		0–0.12	
Engineering coordination		0–0.08	
Engineering quality		0–0.12	
Other special conditions		?	
Basic job condition factor, perfect conditions		1.00	1.00
Total job condition factor			

usually uniform nature. Lower worker ratios are required for difficult work, and for very technical work such as instrumentation and complicated electrical installations.

Lower worker ratios warn of over-supervising. Over-supervision is quickly apparent in dollars and cents. It is much less likely to be overlooked than the subtle loss of greater sums through decreased work efficiency caused by lack of adequate supervision.

Field supervisors must be provided with the information required to do their jobs efficiently. They must be organized as a team with a minimum of overlapping and gaps in responsibility, upheld in their positions and given a sense of participation in the job.

Moving further up in the project organization, the contractor's supervisors, the contractor's home office, field construction group for the owner and all affected departments of the owner's organization must also be coordinated and must operate as a team for best efficiency. Failure to do this will result in increased field labor costs.

Experience during World War II, with a series of very similar plants of large size, indicated that variations in the ability and performance of the top construction supervisor alone can produce a variation in labor cost of about 14%. A very similar example is quoted by C. Tyler in *Chem. Eng.*, Jan. 1953. He stated that two plants of the same type were built by the same contractors at about the same time but 800 mi. apart. On one, there was an underrun of about 4% and on the other, an overrun of 10%. Tyler attributed the difference in the abilities of the superintendents.

Deficiencies in quality and quantity of subordinate field supervisors might also be expected to increase labor costs by somewhere near 14% each. The top of the ordinary range of the supervision element of the job condition factor might be in the order of three times 14% or 42%.

Field Labor

Unfavorable conditions which may arise on a construction job often influence the labor hours for the project. The estimator must be alert to the following factors:

Sometimes plant production cutbacks make it desirable to use operating personnel for construction work. These men are good at their own jobs, but inexperienced in construction work. Hence man-hour requirements increase.

In some plant construction forces, plant regulations permit promotions to mechanics jobs only through the labor gang on a seniority basis. Few men capable of becoming expert craftsmen will choose this route during good times. Hence, a persistent down-grading of competence in the construction force results, unless counteracted by a good apprentice training program.

Variation in output may be expected in different sections of the country. Construction worker output in larger cities, having over 500,000 population, tends to be low. Some variations are due to a current temporary tightness of the local labor market. During boom times, inexperienced workers are hired because nothing better is available.

Bonus and piecework arrangements have produced remarkable results in reducing man-hour requirements for some types of construction work. Field erection of tanks is outstandingly efficient by major tank builders due to their use of piece rates and the policy of heavy bonuses to field supervisors for low cost. Applying incentive arrangements to this work is possible because the quantity and quality of output can be accurately measured.

Other effective incentives are of a less material nature. Competition between crews, between shifts or between similar projects can produce high output and low costs. High efficiencies are sometimes obtained when a positive deadline must be met—provided that job conditions, especially adequate supervision and planning, are not allowed to deteriorate.

Manufactured emergencies, daily emergencies and unrealistic deadlines have a bad effect. Construction men are keen observers and know the difference between actual, unavoidable emergencies and those resulting from poor management.

Much could be said concerning the willingness of labor as affected by job traditions and union rules. Here, the experience of the estimator is indispensible.

In summary, we find the ordinary range of construction worker competence factor is about 0 to 0.35. The willingness element has about the same range, making the total range of the two items 0 to 0.70.

Type of Contract

Lump sum work is driven toward efficiency by the immediate cost to the contractor of inefficiency. Working on a cost plus basis will usually increase labor costs about 5% because of elimination of this driving force. For percentage-fee contractors, the increase may be 10% or more.

Either the percentage-fee or fixed-fee contractor is inclined to shrug his shoulders and accept poor job conditions, especially when he considers the job conditions are due to some act or omission of the owner or engineer. On lump sum work, he will insist on correction of these same conditions.

With or without the contractor's knowledge, these attitudes are almost invariably reflected in the field. However, there are some contractors who handle lump sum and fee work with exactly the same conscientious care and whose employees reflect this policy by working in exactly the same way on both.

On some jobs, lack of complete drawings or the unpredictable nature of the work makes fee arrangements necessary. In these cases, incentive fees can sometimes be arranged which will produce contractor performance equivalent to lump-sum work. These incentive fee contracts are the reverse of the usual percentage-fee arrangements. The more the costs go up, the less the contractor gets. If the costs drop, his fee increases. Usually maximums and minimums are set to prevent unfairness to owner or contractor.

Construction Equipment

Historically, the greatest single factor in reducing the manpower and cost for performing a given amount of work has been the use of construction equipment. Earthmoving is the prime example. Even in the recent period of rapidly rising costs, the increased use of earthmoving equipment, combined with improvements in the size and performance of this equipment has kept costs per unit practically constant. Labor costs will be lowest on projects taking full advantage of

construction equipment such as front-end loaders, fork-lift trucks, cranes and back hoes.

Tools and other minor equipment items have shown similar improvement in recent years. For example: power hand saws, power tampers, steel scaffolding, spray guns, electric drills and power winches contribute to improved efficiency if they can be and are applied to a project.

Tools and equipment must be maintained in good condition if full advantage of their use is to be obtained. Equipment which is out of use because of poor maintenance runs up job costs. Maintenance of small tools and minor equipment is important from an efficiency and safety standpoint.

Loss of efficiency due to lack of major equipment may be 0 to 40%, although special cases can run higher. Lack of adequate small tools and minor equipment can produce losses having a range of 0 to 35%. The tool and equipment maintenance element probably has a normal range of 0 to 20%.

Construction Facilities

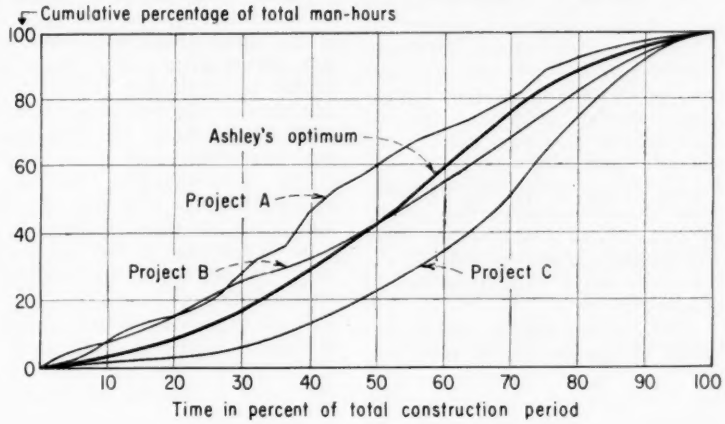
Construction facilities, in good order and well located, materially increase the efficiency of a job. If a workman has to walk a half mile each way when he needs supplies from the storeroom, he will probably spend more time walking than working. Efficient service at the storeroom is just as important. Men lined up waiting to be served are building up man-hours and drawing pay.

Location on the site of change houses, construction offices, maintenance shops and craft shops should be carefully established. Some part of the labor cost of a job is built into it when locations for these facilities are chosen. Portable buildings and trailers can be used to meet shifting location requirements as the work progresses.

General clean-up of the working area is a service which will not only reduce accidents but will increase efficiency. Other services and facilities which can contribute to lower costs are: temporary electrical service, compressed air, heat, telephones, drinking water, messenger service, first aid, fire protection, employment and safety inspection.

Although little factual data are available, it is suggested that lack of effective services and facilities can increase job costs by about 5% for each of the following categories: storerooms and yards, shops and offices, personnel facilities and clean-up, and temporary utilities. The over-all effect for these conditions ranges from 0 to 20%.

Orderly Construction Crew Buildup Gives Well-Run Job



Physical Working Conditions

Job efficiency is decreased by climatic conditions, heat, gases, fumes and proximity to hazardous materials. Loss of man-hours due to weather can be approximated by estimating from weather records the number of lost-time days which will be encountered during the construction period of the project. Assume that about a third of that time will be pay time not effectively worked. Usual ranges will be 0 to 25%. Losses due to process fumes, heat and hazards can run as high as 300 to 400% but usually are in the range of 0 to 40%. Often these affect only a limited portion of the project. Mud, dust and altitude effects are probably in the range of 0 to 15%.

Access to Work

Job efficiency decreases with height because of the vertical travel time and the additional care and equipment required to work safely. Extra costs can be minimized by good planning and the use of good equipment such as adequate steel scaffolding and high speed hoists. Work in deep pits produces a similar loss of efficiency. As a rough rule, the cost of work such as pipefitting and wiring can be considered to increase about 1% for every foot above ordinary reach. This applies up to heights of 40 ft. or so.

Good roads are even more important in these days of high-priced labor and wheeled equipment. All-weather roads, laid down as early as possible, get a project off to a good start. For concentrated industrial plant construction, these should be concrete or some other hard surface. Gravel and other low-order surfaces must be constantly maintained, but are usually the economical solution for dispersed projects. Poor roads increase labor costs from 0 to 10% and up.

Construction Program

A construction rate which is faster than normal may produce a decrease in efficiency due to longer hours, crowding of crews, overrapid buildup and increased difficulty of supervision.

Abnormally fast buildup of crews causes losses. Jobs where employment is soaring seem to develop indigestion. A substantial number of people are wandering around without enough to do, and some who look busy aren't. The graph, shown above, gives actual buildup curves plotted as cumulative percent of total manhours against time in percent of construction period. These are for complete process installations, including foundations, struc-

tural steel, building enclosure, piping equipment and electrical work.

Also plotted is Ashley's* recommended buildup curve for electrical projects costing about $500,000. Curves plotted in this way for well-run jobs should have few sudden breaks and steep sections. Exceptions will be found on the smaller projects where a sub-contractor brings in a good-sized well-trained crew to begin some portion of the project such as steel erection. This will produce a sharp rise in the man-hour curve with little loss of efficiency.

Area loading can be analyzed in terms of the number of field men per 1,000 sq. ft. of work area. A usual rate for jobs costing less than $500,000 is somewhere near five men per 1,000 sq. ft. during the peak weeks of the construction program. Larger jobs have lower apparent rates since not all of the project area is simultaneously active. High concentrations of men result in decreased efficiency; although there is no definite information as to numerical values. Except for emergencies, schedules which require more than seven or eight men per 1,000 sq. ft. are probably not realistic and will almost certainly increase labor costs.

Construction jobs progressing at less than the normal rate have high total costs. Part of this is due to stretching out the period when overhead costs must be maintained, but part of it is due to laxness and bad work habits which develop on a slow job.

Interruptions due to shifting of crews from one part of a project to another, or to emergency repair work can seriously affect job efficiency. When the crews return, they lose considerable time getting workwise. Long interruptions involve the replacement of material, tools and scaffolding which have wandered away.

Waiting time during tie-ins is another source of loss of efficiency. Careful programming and coordination of all the organizations involved will reduce but not eliminate this loss.

Faulty buildup rates can cause losses in the 0 to 10% range. Usual over-crowding can probably cause losses of the same magnitude. Interruptions in the program can cause losses in the 0 to 15% range.

* R. Ashley, "Electrical Estimating," McGraw-Hill, New York, 1956.

Material Coordination

All necessary material should be on hand as required and must be of the correct kind. Otherwise delays result with loss of time and money as crews are shifted from one part of the job to another to work around items which have not yet been delivered or which are not usable. Extreme cases necessitate laying-off crews with the resulting loss of the investment in job education. When such layoffs are necessary, the morale of the remaining men suffers.

Another problem which occasionally arises is the too-early delivery of material. This can cause extra costs due to special unloading arrangements, deterioration in storage, extra warehousing costs, extra weather protection, misuse of materials and loss of identification.

Effect of this job condition may range between 0% to about 12%. If the material situation gets too bad and cannot be corrected, the job should be shut down.

Engineering Coordination

If drawings are available, competent construction superintendents and foremen will study them in advance and layout a program by which the work can be efficiently done. If drawings arrive just before they are needed, this planning cannot be done and job efficiency suffers.

If drawings come in later than required by the construction schedule, there will be times when crews are floating until the required information is obtained. When drawing issue drops too far behind the construction schedule, crews must be laid off with the subsequent costs of loss of morale, re-hiring and retraining.

A check list of questions which can act as a guide in evaluating this element might include:

1. Has a design schedule based on availability of engineering manpower been prepared?
2. Have the design schedule and the construction schedule been coordinated to provide drawings in the order required for construction?
3. Will the scheduled construction starting date give sufficient lead time to the design schedule?
4. Is design completion scheduled far enough ahead of scheduled construction completion?
5. Have procedures been established to assure release of drawings and other types of design information to the field at the optimum timing ahead of actual construction?

Design information availability element of the job condition factor may exhibit variations from 0 to 30%, with usual values ranging from 0 to 8%. The higher values are reached only when faulty planning or considerations other than efficiency force construction progress at rates well beyond the optimum with respect to design progress.

Engineering Quality

Closely associated with the timely receipt of design information is the necessity for accuracy and completeness. Actual errors in engineering information are not as frequent as are ambiguities and omissions. With fully detailed, easily read drawings, the field work goes ahead without holding up crews for field interpretation or detailing by job supervisors, foremen or engineers.

When actual errors exist and are not caught by the design checkers or field supervisors, the cost of removing and replacing faulty work may produce a substantial increase in the labor and materials costs of the job.

Some types of design information which, while not indispensable, can contribute to the efficiency of field work are:

1. Installation instructions from equipment manufacturers.
2. Installation instructions prepared by design engineers.
3. Cut-over and tie-in procedures established by design engineers.
4. Special construction procedures developed during design.
5. Borings and other sub-surface surveys.
6. Surface contour and general area maps.
7. Specifications, especially painting and insulation.
8. Flow diagrams.
9. Single line electrical diagrams.
10. Equipment and instrument lists.
11. Descriptive sections of design reports.

For the quality of engineering information received from the design departments of most corporations and consultants, this element of the

Variables Control Labor Costs

Craft of workmen
Local pay scale
Amount of overtime
Premium pay for overtime
Travel pay agreements
Number of foremen and pushers
Federal and state payroll taxes
Compensation insurance premiums
State revenue payroll tax
Union benefit fund and vacations
Construction equipment cost
Contractor's overhead*
Contractor's profit*
Construction tool and supply cost*

*On large jobs these items are included in field expense.

job condition factor will probably vary from about 0 to 12%. Attempts at partial engineering can raise this to 100% or more.

Other Special Conditions

After considering the listed job conditions, the estimator should study his project for any special conditions which may have an adverse or a beneficial effect on labor performance. As an example: on some electrical work there must always be a man on the ground to watch the movements of men on hot equipment.

How to Use These Factors

Total job condition factor is the sum of perfect job condition factor of 1.00 plus the probable decimal increase in labor hours produced by each job condition. Relative range of all the job conditions affecting labor hours is given in the table on p. 121. A convenient form can be prepared from the table to itemize the job factors for each project. On this form, space is provided to list the probable decimal increase in labor hours produced by each job condition as well as a few notes on the conditions expected for the project. Sometimes job conditions are different enough for different parts of the project that it may be necessary to compute more than one job condition factor.

These check lists should be kept until the project is completed. By comparing actual and estimated conditions and man-hours, the accuracy of future appraisals of job conditions and their effects can be improved.

Establish Man-Hour Costs

Effective pay rate is defined by the following equation:

$$\text{Effective pay rate} = \frac{\text{Total labor cost}}{\text{Man hours}}$$

Pay and time of field superintendents, time-keepers and general foremen are excluded from this calculation.

Since there are at least 14 variables affecting the cost of a man-hour, it is easier to determine an effective pay rate by analysis from past similar jobs. Great care must be taken, either to be sure that the job at hand is identical with the job of record as far as pay conditions are concerned, or that necessary corrections are made to allow for the new conditions.

As an aid in establishing effective pay rates, and in correcting recorded effective pay rates to changed conditions, each of the variables will be individually discussed.

Craft of Workmen

Construction work has traditionally been performed by craftsman specializing in one particular type of work. With the passage of time the lines of demarcation between work to be performed by the several crafts have been formalized to a high degree.

The working rules not only specify what crafts shall be employed on certain work, but also what grades of mechanics shall be employed. The rules specify ratios between foremen, mechanics, helpers and apprentices. Working rules may also make necessary such procedures as using electricians in equal numbers with riggers when moving large transformers, or having an operating engineer for every air compressor on the job. Relationships between the unions and the contractors on the job have a tremendous influence on the severity or looseness with which the rules are interpreted.

The estimator with considerable field experience usually knows pretty well what trades will be needed to accomplish a given project. The less experienced estimator has recourse to records or advice from field men.

Local Pay Scale

For a general idea of wage variations across the country consult *Engineering News-Record*. However, it is best in estimating for a new project to get a wage list for the exact location where the work is to be performed. This can be obtained from the local Trade Union Council, the State Employment Office or the local U. S. Department of Labor Field Office.

For large projects it is necessary to check to be sure that the local unions for which the rates are quoted can furnish enough men. If plant maintenance or construction workers are used, the plant supervisors can furnish necessary craft and wage information. Here again it is necessary to check to be sure that sufficient manpower is available in excess of that needed for current plant work. Otherwise it may be necessary to use seasonal contractor's men at higher average pay rates.

Amount of Overtime Work

Average effective pay must be corrected to show the affect of workweeks extended to attract labor to the job, or to expedite the work when the working area is so restricted that additional men cannot be utilized to advantage.

For operations involving heavy construction equipment, longer working hours are often economical, even with the resultant increase in average pay and decrease in worker efficiency.

Construction away from industrial areas sometimes involves travel pay. In cases where equipment manufacturers provide field erection crews, their agreements usually stipulate that the men be paid transportation, travel expenses, travel time and living expenses. These are part of the labor cost of the job.

Foremen and pushers are paid more than the craftsmen they supervise, increasing the average effective pay rate by the wage differential divided by the average number of men in a crew.

Federal and State Payroll Taxes

Federal Old Age Benefit Tax paid by the employer is 3% on all wages and salaries. This tax money pays for the various Social Security

benefits to employees. Unemployment compensation insurance differs from state to state. Some have no tax for this purpose, others have a tax as high as 3%.

Some states as a means of obtaining revenue have established a tax on construction payrolls. This is usually about 0.5%.

Workmen's Compensation

Workmen's compensation insurance covers job accidents to employees. It varies from about ½% to over 30%, depending on the type of work, the state where it is being done and the accident record of the contractor. The *Engineering News-Record* publishes in the annual "Construction Costs" number a complete tabulation of compensation rates by craft and by state.

Union Benefit Fund

In addition to the provisions for accident, death, retirement and unemployment compensation established by state and federal laws, many unions have their own benefit funds and payments. Some New York unions currently have a 3% welfare and a 20¢/hr. pension levy. Rates elsewhere are usually less.

Contractor's Overhead

For small projects, it is usually convenient to consider the contractor's overhead as being a percentage of the labor cost of a man-hour, and to include it in the effective pay rate. On these smaller jobs the contractor cannot possibly keep accurate individual job overhead records, so he charges the job a percentage based on his annual totals for all the work he performs. Contractor's overhead on small projects varies from 10% to 20%.

Although overhead percentages are usually computed and billed on total job costs, the actual overhead expenditure required for all-labor contracts is greater than for a similar dollar volume of labor-and-material contracts. For large projects the contractor's overhead should be budgeted in detail as part of field expense and not considered as part of the average effective pay rate.

Contractor's Profit

Most contractors on small to medium work try to get a 10% profit on labor and material. Profit margins on the larger jobs are less. Actual average profits for contractors across the country are in the 4% range during normal times.

For small jobs the contractor's profit can be included as a part of the effective pay rate. For the large jobs the contractor's profit is estimated as a lump sum to be included in the field expense budget.

Use Labor-Material Ratios to Find Labor Costs

New project information:	
Estimated cost of maintenance shop lighting material, current prices	$10,000
Expected ENR construction cost index	650
Probable job condition factor	1.20
Similar project information:	
Standard labor-material ratio at ENR of 600, JCF of 1.50 from lighting installation in similar shop built in Chicago in 1944	0.40 MH/$M
Man-hour computation:	
Job labor-material ratio, new project $0.40 \times (1.20/1.50)\ (600/650) = 0.296$, say 0.30	0.30 MH/$M
Man-hours to install lighting $0.30 \times \$10{,}000$	3,000 MH
Labor cost computation:	
Average effective pay rate	$6.00/MH
Estimated labor cost is $3{,}000 \times \$6$	$18,000

Construction Equipment Cost

Construction equipment cost usually appears in the labor column of the construction ledger. This is based on the consideration that construction equipment is a replacement for human labor. For preliminary estimates, the cost of supplying workmen with equipment such as welding machines, trucks, cranes and bulldozers can be included in the average effective pay rate. For more detailed estimates, machine-hours and machine-hour costs are determined very much as if each machine represented an hourly-paid worker.

Machine-hour costs include rental, or depreciation, as well as operating costs. On large projects a field expense budget is established for the control of equipment operating costs. Individual sub-accounts of the project are charged for the use of machines on an hourly rental basis. Appropriate field expense accounts are credited.

On small jobs construction tools and supplies may be considered part of the contractor's overhead and as such included in the effective pay rate. Larger jobs should have lump sum items in the construction expense budget to cover tools and supplies.

Accounting Practices

Company accounting practices must be conformed to with respect to charging items to operations, to labor, to material or to overhead. The estimator's problem is to forecast the cost figures as they will be entered on the company's books. Therefore, effective pay rates must be computed on a corresponding basis.

Usually these accounting practices are so tightly built into company procedures that the estimator must conform. Occasionally he may be able to point out changes which will improve the realism with which the construction cost records reflect actual cost to the company.

The sample computation shows how an effective pay rate can be built up from information concerning local pay conditions.

Average craft base rate		$3.09
Foremen and pushers differential	2½%	0.08
Social security	3%	0.09
Unemployment insurance	3%	0.09
Workmen's compensation, avg	3%	0.09
Expendable tools	½%	0.02
Construction equipment cost	5%	0.15
Overhead (computed on base pay plus equipment)	10%	0.33
Profit (computed on base pay plus equipment plus overhead)	10%	0.38
Average effective pay rate		$4.32

For our purpose, a labor-material ratio can be defined as the number of field man-hours required to install a dollar's worth of material or equipment. Any construction labor performed on the plant site is included. Work done off the site is considered to be part of the material cost of the job.

A standard labor-material ratio is the number of field man-hours required under standard job conditions to install the material that could be purchased for one dollar if the ENR Construction Cost Index were at 600.

A job condition factor of 1.50 has been arbitrarily established as standard. It represents conditions about like those encountered when making new installations in operating industrial plants. Construction work on new sites, with good working conditions, will have job condition factors closer to 1.20. Work under poor job conditions will have ratings above 1.50.

Assume, for the purpose of illustration, that a lighting system has been installed in a building during the initial construction of a plant and that the records show that 0.32 man-hours were required for every dollar's worth of material installed. If the job condition factor for this initial work was 1.20, and assuming for simplicity that the ENR Construction Cost Index was 600, then the standard labor-material ratio for this work would be—

$$0.32 \times 1.50/1.20 = 0.40 \text{ MH/\$M}$$

If a new bay is to be added to this same building on a rush basis, with other unfavorable job conditions, the job condition factor for the new work might be 2.00. Assuming the cost index is constant at 600, the job labor-material ratio for the addition would be:

$$0.40 \times 2.00/1.50 = 0.53 \text{ MH/\$M}$$

Standard labor-material ratios must be corrected to a common ENR Index base of 600 because of the variations in the amount of material which can be purchased for a dollar. Assume for the purpose of illustration that the lighting had been installed in the building mentioned above at a time when the ENR Index was 400 under job conditions represented by JCF of 1.50, and that under those conditions it took 0.60 field man-hours per dollar's worth of lighting material to do the installation. The standard labor-material ratio for the job would then be:

$$0.60 \times 400/600 = 0.40 \text{ MH/\$M}$$

This standard ratio is less than the record ratio because at ENR 600 a dollar buys less material than at ENR 400. Therefore, less labor will be required to install that dollar's worth of material. No job condition correction is required in this illustrative case, since the actual job conditions have been assumed to be about equal to standard.

Standard ratios should be computed for each subdivision of each job of record. They should be tabulated in accordance with the standard account classifications. Each entry should have a brief description of the type of work done and the type of project.

Correcting ratios to a standard base and grouping them in this fashion improves their usefulness by permitting intelligent interpolation, generalization and averaging. When a sufficient background of such information has been built up, it is not too difficult to select the type of work and job of record most similar to the one at hand and to correct the standard ratios to the job conditions and cost conditions of the current work.

Labor man-hours are computed by multiplying job labor-material ratios by the applicable material dollars. Labor dollars are computed by multiplying labor man-hours by the applicable effective pay rate.

Detailed Unit Labor Pricing

Detailed unit labor estimates with an accuracy of better than plus or minus 3% are a necessity for contractors bidding on lump sum work. They are also needed by engineers for comparisons of alternate designs. Unfortunately these estimates are:

- Expensive—their cost is on the order of 1 or 2% of the labor cost of the project.
- Slow—all drawings and bills must be complete before the estimate can be completed. With large jobs and the usual shortage of estimators, several weeks may be required to complete the estimate after drawings are made.
- Difficult—construction work has such infinite variety that an estimator must have special experience and voluminous records to be expert in a single portion of the entire labor estimating field.

Usually the owner's engineers, estimators and management need capital cost estimates for (a) determining probable percentage return of a project, (b) checking bid prices and (c) arranging for financing.

For these purposes, an estimate of total labor and material with an accuracy on the order of plus or minus 10 to 15% is often adequate. Labor-material ratio methods may be used to save project completion time and estimating expense in such cases.

Detailed unit labor estimates will usually be required for the smaller jobs and for comparing alternate designs.

Sources of detailed labor estimating information are scattered through many publications. These can be located by means of the references at end of this report. However, the bulk of all labor cost information is in contractor's and estimator's files and is generally inaccessible.

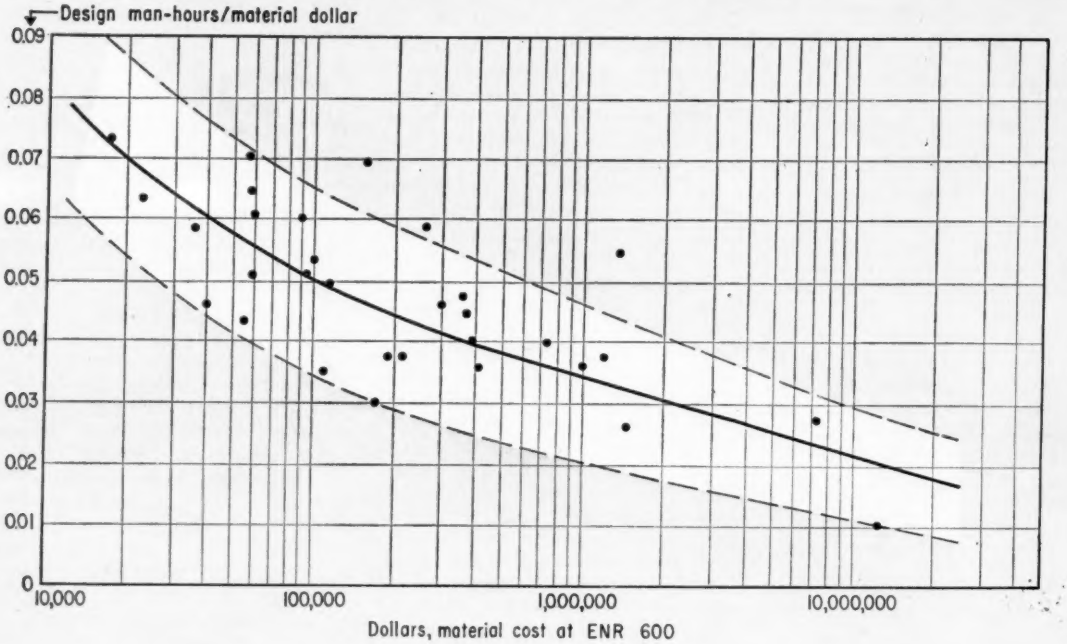
In some cases where a detailed estimate is required, the drawings can be sent out for lump-sum bids. Bids on alternate designs can also be requested. Results will be satisfactory, provided contractors need the work to bid right. In fairness to contractors and because preparing estimates is expensive, bids should be requested only on work which has a better-than-even chance of being authorized for construction. Alternates should be kept to a minimum and alternate bids requested only when it is impossible for the engineer to appraise the relative cost of alternates in some other way.

Coming

In Part II of this report, the author will discuss:

- Contingencies
  - Function of a contingency
  - Uncertainty of projects
- Estimating Methods
  - Equipment ratio
  - Layout
  - Preliminary bill
  - Detailed unit cost
- Appraisal of Methods
  - Required project data
  - Time to make estimates
  - Relative accuracy of estimates

Estimate Design Time From Project Material Cost at Base ENR Index



Include Design and Field Expenses

Design expense includes all office engineering and drafting required to prepare and issue construction drawings, specifications and bills of material. It does not include preparation of the first issue of the design report nor any of the preliminary engineering studies preceding the design report. Neither does it include field engineering work such as:

- Property survey
- Topographic survey
- Hydrographic survey
- Subsurface survey
- Inspection and testing
- Field layout
- Field engineering liaison

Design expense includes engineering performed by either company or associate engineers. Work performed by company engineers for small projects is part of the general expense of operating the company.

Estimates of Design Expense

Amount of design time required for a project is a function of a number of variables such as size of project, type of project and productivity of engineers and draftsmen.

Size of project is the most dominant variable. There are several possible measures of project size. The graph of design man-hours per material dollar against material has slightly narrower deviations than plots against labor or against labor and material.

The graph at top of this page of design man-hours per material dollar against material cost at ENR 600 for design projects of record shows a distinct tendency toward lower values for the larger projects. There are wide deviations of individual points due to variations in type of project and productivity. Design man-hours for a new project can be approximated from this diagram. However, the estimator must exercise considerable judgment in classifying the project design as easy, standard or difficult.

When the average cost of a design man-hour including the engineering overhead and engineering fee is known, design cost can be estimated from the design man-hour curve. The following analysis illustrates the method:

Estimated material cost of project is $1 million. For estimate basis, use ENR index of 820. Hence, material cost at ENR 600 is $1 million $\times$ 600/820 or $733,000.

Assuming standard difficulty, we find design man-hours per material dollar equal 0.036 from the graph. Design man-hours for the project equal 0.036 $\times$ 733,000 or 26,300.

Cost per design man-hour is $7.00 which represents design time at

Compare Representative Field Expense Charges of Cost-Plus Contracts

	Total Labor and Material	Labor Percentage*			Material Percentage*	
		Labor, Taxes and Insurance	Field Overhead	Profit	Overhead	Profit
Concrete	$8,000	15%	10%	9%	10%	9%
Concrete	———	10.5%	0%	10%	——	——
Concrete block building	93,700	7%	10%	9%	10%	10%
Structural steel	83,800	12%	12%	10%	——	——
Structural steel	———	11%	15%	10%	——	——
Office partitions	5,000	Actual	10%	9%	10%	9%
Roofing	10,000	8%	17.5%	10%	17.5%	10%
Piping	3,500	Actual	10%	10%	——	——
Piping, gas and water	12,000	13%	10%	10%	10%	10%
Piping	12,000	8%	15%	6%	——	——
Piping	18,000	10%	15%	10%	——	——
Instrumentation	13,000	10%	10%	10%	——	——

* Percentages are applied progressively to the respective labor and material costs.

$3.50/hr. plus 100% overhead and engineering fee. Therefore, estimated design cost equals 26,300 × $7.00 or $184,000.

Since the estimated material cost of the project includes an allowance for unlisted items, the estimated design cost automatically includes the same percentage allowance for engineering of extras. Because of the wide divergence of actual project design man-hours from mean values, the preceding method should be used only for preliminary estimates.

For a layout estimate, more accurate estimates of design cost can be made after the project engineer completes the design report and its list of drawings required for the project. Drawings should be classified as to type of work and man-hours per drawing assigned by the project engineer. When estimated in this way, an unlisted items percentage should be added to the design man-hours to take care of the unforeseen.

When a preliminary bill estimate can be made, much of the design engineering is complete. The actual design cost-to-date, plus the estimated cost of completing the drawings in progress and the drawings not begun, plus a contingency percentage based on the current uncertainty rating, gives the probable cost of the whole. Overoptimism with regard to percent completion should be avoided.

When a design has advanced to the point where a detailed cost estimate can be prepared, almost all of the actual design cost is known. The unlisted items allowance which is relatively small at this stage is added to take care of revisions during construction.

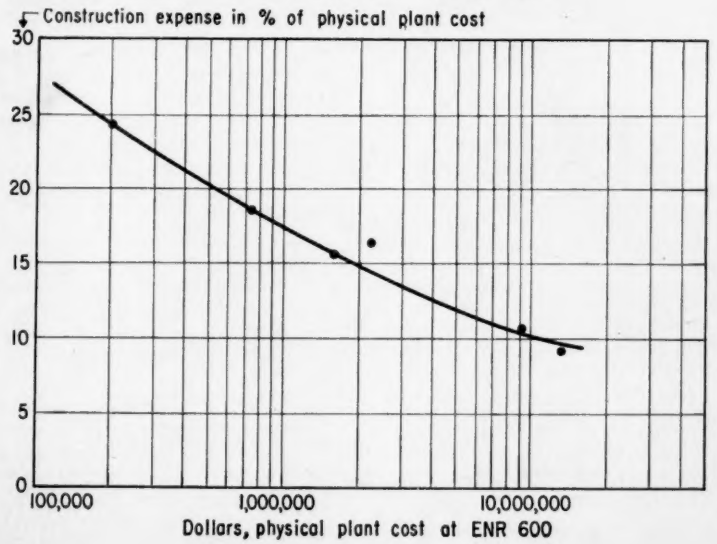
Define Field Expense

Field expense is made up of construction overhead and engineering costs connected with field work and not specifically chargeable to any single part of a project. These cost items and corresponding account subdivisions are:

Field Engineering
- Field engineering liaison
- Layout survey
- Property, topographic and hydrographic surveys
- Subsurface surveys
- Inspection and testing

Procurement
- Purchasing salaries, expenses and fees

Field Costs of Constructors Reflect Project Size



- Transportation of materials, supplies and equipment when unassignable to specific subaccounts
- Receipt, storage and issue of materials
- Expediting salaries and expenses
- Material coordination salaries and expenses
- Stores when not chargeable to specific subaccounts

Construction Equipment
- Major construction equipment purchase and sale
- Major construction equipment rental expense
- Tool and minor construction equipment purchase and rental
- Supply purchase including office supplies
- Repair and maintenance of major construction equipment
- Receipt, storage, repair and issue of tools, supplies and minor construction equipment
- Construction equipment rental credits

Temporary Facilities
- Buildings
- Stores, equipment and enclosures
- Water supply and distribution
- Sanitary facilities
- Heating
- Electrical supply and distribution
- Roads, walks and parking
- Compressed air supply and distribution
- Office equipment

Services
- Field supervision
- Cost and timekeeping
- Stenographic and messenger service
- Salvage
- Telephone, telegraph, prints, photographs and publications
- Plant protection
- First aid and safety
- Employment
- Clean-up when unassignable to specific subaccounts

Administration and Fees
- Contractor's fee and bond
- Legal fees
- Taxes except payroll taxes
- Insurance except workmen's compensation and other payroll-tied insurance
- Permits
- Employee relations
- Public relations

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Invisible Field Expense

Estimating field engineering and construction expense is especially difficult because certain items may or may not be considered part of a job's costs. These items depend on circumstances and company policy.

For this reason, construction programs may involve booby-traps for the estimator. Plant construction programs go along for years getting free compressed air, electricity, guard service and other overhead expense items for construction work. Then a really big job comes along. The plant is to be doubled in size. As the construction force builds up, the plant operators start to complain.

How to Estimate Field Expense

Preliminary estimates of field expense for projects under $1 million can be made by applying appropriate percentages to material and labor costs.

For small projects where detailed field expense records are impractical and the owner is supplying all materials, the labor contractor's profit and overhead can be computed as a percentage of the field labor payroll and included in the effective pay rate.

If the contractor is purchasing part of the materials, he will charge a percentage of these items to cover his overhead and profit. If the amount is significant, allowance can be made for it in estimating material cost.

The table on previous page shows some percentages which have been charged by cost-plus contractors on industrial work. Some of these contractors use identical percentages for labor overhead and material overhead. Actually the overhead expense items chargeable to labor will amount to about 3.5 times those chargeable to the same number of dollars of material.

Even when labor overhead and profit percentages are included in the effective pay rate, the list of account subdivisions for field expenses should be scanned for major items which may later appear in the construction ledger as charges to the project. For example: jobs in the $100,000 to $500,000 range will often require the full-time services of an owner's field liaison engineer and sometimes a full-time accountant. Other field expenses will appear as the jobs increase in size. Such items can be estimated from data filed by account number.

When projects cost much over $1 million most of the field expense items begin to assume such proportions that they can no longer be obtained on a free-loader basis and fewer are hidden in direct labor cost. To handle these jobs properly and to get the best performance from the work force requires a more complete field organization. Its cost will be more than repaid by decreased labor cost and early completion.

In terms of percentage of total physical plant cost, the graph on p. 129 gives the field expense for a completely self-supporting field construction organization. The figures include contractor's home office overhead and profit. Physical plant is defined as the labor and material cost of the project at ENR 600 excluding design and field expense.

When time and available information will permit, field expense should be estimated by drawing up a detailed field expense budget. This is also a necessary step in planning the project. The completed budget is used as a management tool to control actual field expenditures.

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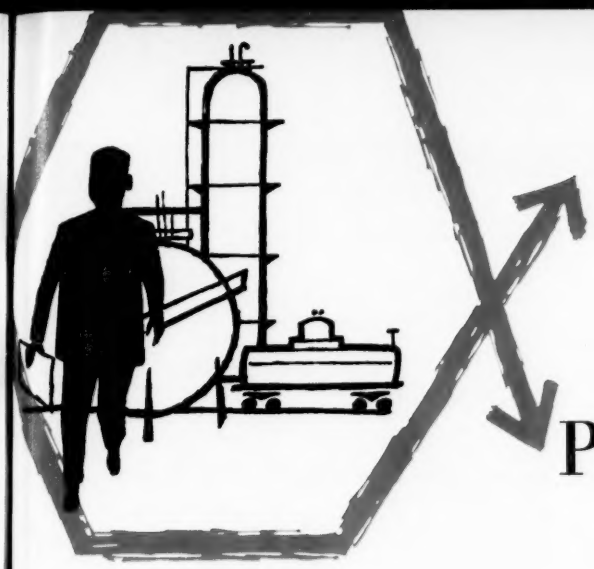


Systems Engineering, Part 2

Process Research

The first step in the systems-planned plant is study of the process reaction kinetics. Here's how to do it.

THEODORE J. WILLIAMS, Monsanto Chemical Co., St. Louis, Mo.

Joe X. Smirk is a project engineer with Quandary Chemical Co. He's designed, built and started up more plants in his 20 years with them than he cares to remember. But when Joe entered his office after a busy week-end, he discovered a fresh note on his desk:

MEMO

FROM: The Management
TO: Joe X. Smirk
1. Chemical Research Dept. has discovered a new chemical product P.
2. Based on preliminary data on the properties of P, Sales Development Dept. predicts sales of 40 million lb./yr. Since product is patentable, our company can develop the full market.
3. Design and build a plant for the production of 40 million lb./yr. of P. Use the systems engineering group to extent you think feasible.

". . . to extent you think feasible." Joe sighed.

THE FOLLOWING steps should result in closest working cooperation of chemical research and systems engineering personnel and best use of computer aids in determining reaction mechanism and kinetic models of processes:

1. Summarize available knowledge of the reaction, including a thorough literature search. Particularly important here is determination of the state of completeness of the reaction mechanism for the process.

2. Through joint consultation of research and systems personnel, outline a series of experiments for elucidating areas where knowledge is incomplete. Especially valuable here are batch isothermal runs for which composition patterns *vs.* time can be obtained.

3. From preliminary investigation of the data, determine as many as possible of the conditions which the reaction mechanism must fulfill.

4. Write down the chemical and mathematical relationships governing each possible, chemically practical mechanism which satisfies step 3 restrictions.

5. Where possible, procure additional experimental data to elucidate contradictory points in reaction mechanisms proposed.

6. By computer analysis, determine best values of kinetic coefficients for each of the reaction mechanisms which still appear possible. By judging "closeness of fit" of computer-derived curves to the experimental curves, choose *most probable* mechanisms.

Process Research

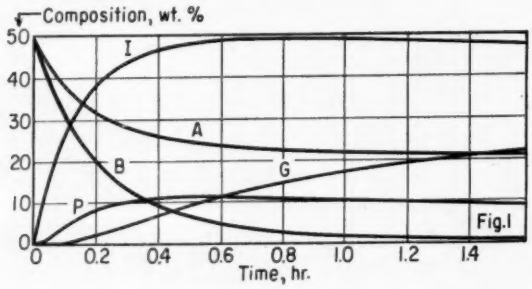
You can readily see some great differences between future and present process research methods. Instead of the chemist working out probable yields and best over-all reaction schemes and conditions by many lab reactions, he will carry out only a select few highly instrumented runs, obtaining as complete chemical analyses *vs.* time as possible. Resulting data will be reduced on computers to derive the most complete kinetic reaction mechanism possible with the available data and to obtain the pertinent reaction constants as functions of temperature and other variables.

Derivation of the complete reaction model opens the way for detailed computer simulation of the process to determine effect of all process parameters on yields and byproduct formation. This allows optimum

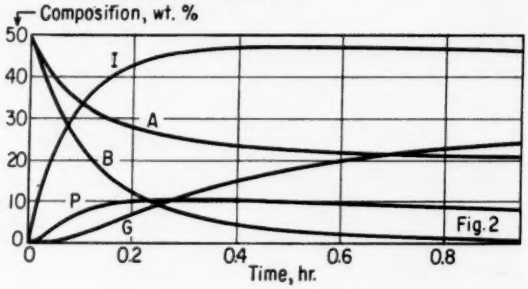
Chemical Research Shows This About P—Table I

1. Reactants A and B are only two needed for reactions which produce P.
2. In addition to P, an intermediate fraction I and heavy oil G are produced.
3. Reaction rate becomes appreciable at about 150 F.
4. A, B and P have molecular weights of 100.
5. G has molecular weight of 300.
6. Molecular weight of I varies. It averages about 190 under conditions of complete reaction.

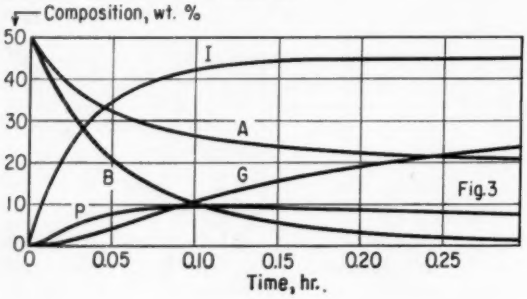
Batch Reaction at 120 F.



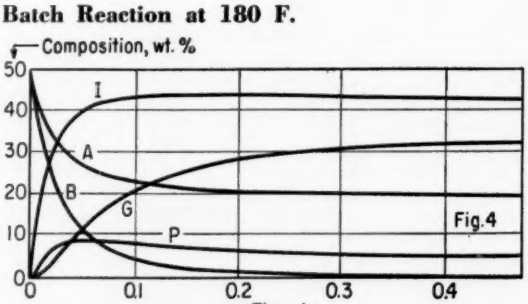
Batch Reaction at 140 F.



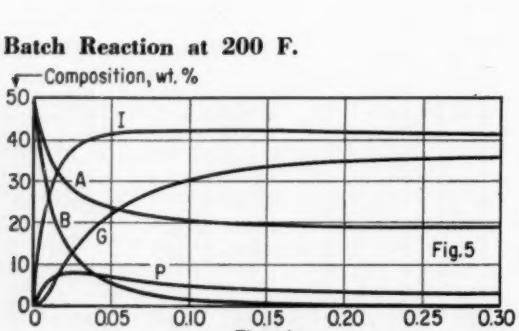
Batch Reaction at 160 F.



Batch Reaction at 180 F.



Batch Reaction at 200 F.



Scheme 1 for Reaction Mechanism—Table II

1. Chemical reactions.

$A + B \rightarrow C$, reaction coefficient k_1 (1)
$C + B \rightarrow E + P$, reaction coefficient k_2 (2)
$P + C \rightarrow G$, reaction coefficient k_3 (3)

2. Differential equations governing mechanism.*

$dA/dt = -k_1 [A] [B]$ (4)
$dB/dt = -k_1 [A] [B] - k_2 [C] [B]$ (5)
$dC/dt = k_1 (M_C/M_A) [A] [B] - k_2 (M_C/M_B) [C] [B] - k_3 [C] [P]$ (6)
$dE/dt = k_2 (M_E/M_B) [C] [B]$ (7)
$dP/dt = k_2 (M_P/M_B) [C] [B] - k_3 (M_P/M_C) [C] [P]$ (8)
$dG/dt = k_3 (M_G/M_C) [C] [P]$ (9)

3. Additional assumptions.
Mol. wt. of intermediate compounds: C, 200; E, 200

4. Relationships between amounts of each component present at any time, derivable from assumed model.

$C' = 2 (A_o - A)$, where C' is total C produced (10)
$C = C' - E - 2G/3$ (11)
$E = 2P'$ (12)
$P' = P + G/3$ (13)
A_o is initial amount of A.

*Eqs. 4, 6, 8 and 9 also are contained in the kinetic model for scheme 2, Table III.

Scheme 2 for Reaction Mechanism—Table III

1. Chemical reactions.

$A + B \rightarrow C$, reaction coefficient, k_1 (14)
$B + C \rightarrow E + P$, reaction coefficient k_2 (15)
$B + E \rightleftarrows H + J$, forward coefficient k_4, backward coefficient k_5 (16)
$C + P \rightarrow G$, reaction coefficient k_3 (17)

2. Differential equations governing mechanism.

$dB/dt = -k_1 [A] [B] - k_2 [C] [B] - k_4 [E] [B] + k_5 (M_B/M_J) [H] [J]$ (18)
$dE/dt = k_2 (M_E/M_B) [C] [B] - k_4 (M_E/M_E) [E] [B] + k_5 (M_E/M_J) [H] [J]$ (19)
$dH/dt = k_4 (M_E/M_B) [E] [B] - k_5 (M_E/M_J) [H] [J]$ (20)
$dJ/dt = k_4 (M_J/M_B) [E] [B] - k_5 [H] [J]$ (21)

3. Additional assumptions.
Mol. wt. of intermediates: C, E, H, 200; J, 100

4. Relationships between amounts of each component present at any time, derivable from assumed model.

$C' = 2 (A_o - A)$ (22)
$C = C' - E' - 2G/3$ (23)
$E' = 2P'$ (24)
$E = E' - H$ (25)
$J = \frac{1}{2}H$ (26)
$J = \left\{M_I [I] - M_G ([H] + [E] + [C])\right\}/M_J$ (27)
$P' = P - G/3$ (28)

processing conditions to be specified long before any final plant design or plant tests are made. Inclusion of reactor and other plant unit dynamics along with heat and mass transfer relationships in the computer simulation can eradicate the bug-a-boo of scale-up which has pestered plant designers for so long.

Such investigations will allow us to eliminate the expense and time of use of the pilot plant in scale-up. True, the pilot plant will still be valuable for production of the product for market development, but its use as an intermediate step in designing and building the producing plant will no longer be necessary.

Let's now discuss development of the reaction kinetic mechanisms and associated reaction rate coefficients of our hypothetical process to show how process research fits into the systems engineering scheme.

Lab Furnishes Experimental Data

In preliminary experiments, the chemists have already determined basic process information contained in Table I. After considering these data, the systems engineering group and the research group jointly decide on a program of five isothermal batch reactions. Every effort is made to obtain as complete an analysis as possible of composition of the systems *vs.* time.

Batch temperatures of 120, 140, 160, 180 and 200 F. are selected. Best smooth curves of the resulting analyses are presented in Figs. 1-5.

To carry out the mathematical manipulations of the data which are necessary for the numerical analysis recommended here, it's convenient to express compositions of the various components in weight fractions, rather than the usual mole fractions.

Conditions for Reaction Mechanisms

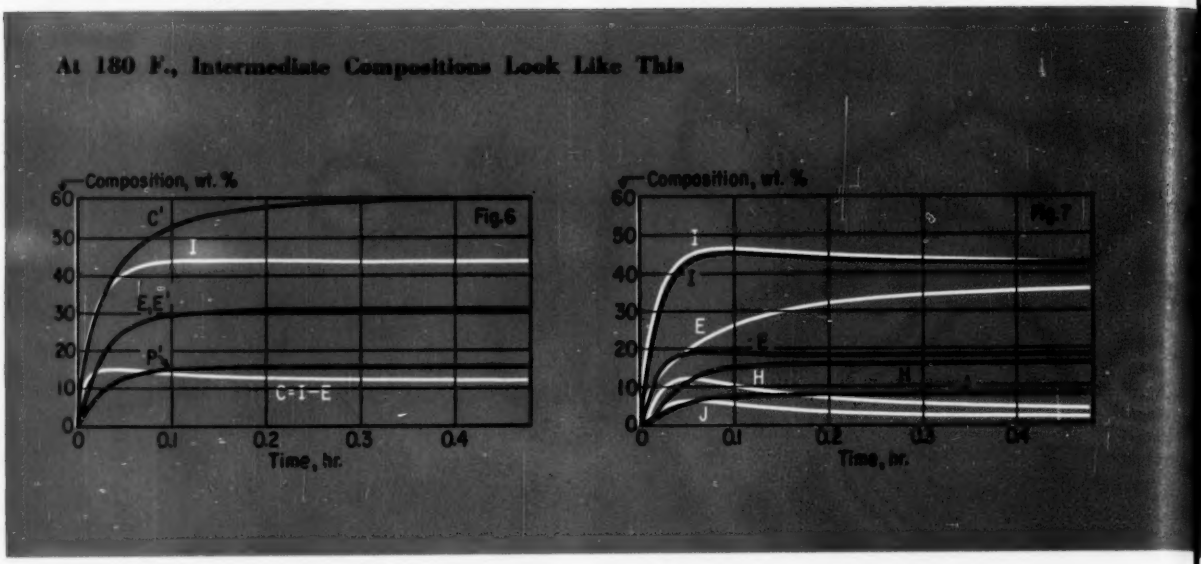
Quick inspection of the data in Figs. 1-5 and Table I suggests many possible reaction mechanisms. Rather than develop and consider each of these in turn, it is better to list general reaction characteristics gleaned from the data. This list should greatly narrow the possible choices. For our case,

1. Since molecular weight of the intermediate fraction I is approximately twice that of either reactant A or B, and since both reactants have essentially equal rates of utilization at the start of the reaction, I must be formed initially from direct combination of A and B.

2. Since much larger amounts of B than A are eventually used up in the process, B must enter into successive reactions.

3. A does not enter into successive reactions since no more is used up once all B has been exhausted.

4. The variable molecular weight indicates that intermediate fraction I is composed of two or more compounds or complexes or both. Also, at least one of these components may take part in a succeeding reaction while another does not, because I is reduced from its maximum value as the reaction proceeds but does



assume some final steady value. This latter situation might also be explained by an equilibrium reaction involving one or more of the components of *I*.

5. Product *P* and heavy oil byproduct *G* are formed by succeeding reactions as evidenced by their definite order of appearance in the reaction.

6. Reactant *B* is not directly involved in the production of heavy oil *G*; it continues to form after *B* has been exhausted.

Reaction Mechanisms Proposed

Two possible reaction mechanisms which satisfy the findings listed above are presented in Tables II and III. Included are pertinent chemical reactions assumed and differential equations which specify course of the reaction and amount of each component if carried out in a batch reactor.

Reaction scheme 2, with component *J* whose molecular weight equals 100, offers a possible explanation for the known variation in molecular weight of the intermediate fraction. As yet, reaction scheme 1 gives no such explanation.

Having selected a tentative reaction scheme, we can operate on data of Figs. 1-5 to determine some possible compositions of components of intermediate *I*. Part 4 of Tables II and III presents relationships which permit such action. Figs. 6 and 7 present these intermediate compositions for the 180 F. run, Fig. 4. Fig. 6 shows total amount of *C* formed, *C'*, *vs.* time for both reaction schemes and the total amount of *E* at any time during the reaction.

From these, we obtain the actual amount of *C* available at any moment—also shown in Fig. 6. Notice that a residual amount of *C* remains after the reaction has apparently ceased. This is contrary to reaction scheme 1, Table II, whose assumed kinetics shows the intermediate *C* being used by subsequent reactions. This discrepancy must be resolved or else scheme 1 must be amended or discarded. More on this later.

Since analyses for individual components *C*, *E*, *H* and *I* are missing, resolution of individual compositions for scheme 2 will be considerably harder than for scheme 1. The main difficulty will be in resolving between components *E* and *H*.

However, there are several theoretical considerations which can help us. First, if the backward reaction coefficient k_5 of scheme 2 is of any appreciable size compared with k_4, components *H* and *J* must disappear along with component *B*. On the other hand, if k_5 is very small compared with k_4, then *H* and *J* may exist after *B* has been exhausted. In this case, Eq. 15 effectively becomes

$$B + E \rightarrow H + J \qquad (15a)$$

Both cases should be investigated.

Fig. 6 presents, as for scheme 1, values of *C'*, *P'* and, for scheme 2, *E'*. Fig. 7 presents all we can tell about components *E*, *H* and *J* without further work.

Developing the Kinetic Model

Actual proof of the probable reaction scheme requires finding a set of kinetic coefficients which are theoretically reasonable over the complete range of existing data. Questions and discrepancies raised in preliminary studies of the process must also be resolved by further study of the model.

The best method of proving a reaction scheme is by solution of the set of simultaneous differential equations describing the reaction. These are repeated for different values of each kinetic coefficient until best fit of the experimental data is obtained.

For all except the simplest cases, use of computers is necessary to effect these solutions. The analog computer is especially recommended because it readily accepts changes in kinetic coefficients. Too, graphical presentation of resulting solutions makes preliminary judgment of "closeness of fit" by eye very convenient.

An attempt to duplicate the data of Figs. 1-5 through

Determine Preliminary Coefficients—Table IV

Scheme 1

$$k_1 = (dC'/dt)_1/[A]_1[B]_1 \quad (29)$$

$$k_{1,\text{avg}} = [C']_1/\int_0^t [A][B]\,dt \quad (29a)$$

$$k_2 = \tfrac{1}{2}(dE/dt)_1/[C]_1[B]_1 = (dP'/dt)/[C]_1[B]_1 \quad (30)$$

$$k_{2,\text{avg}} = ([E]/2)_1/\int_0^t [C][B]\,dt \quad (30a)$$

$$k_3 = (3/2)(dG/dt)_1/[F]_1[C]_1 \quad (31)$$

$$k_{3,\text{avg}} = (3[G]/2)_1/\int_0^t [F][C]\,dt \quad (31a)$$

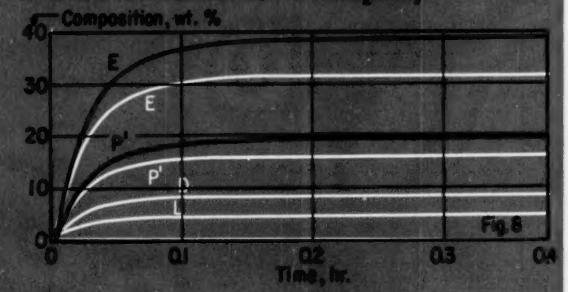
Scheme 2

Coefficients k_1, k_2 and k_3 same as above, except that F' is substituted for E.

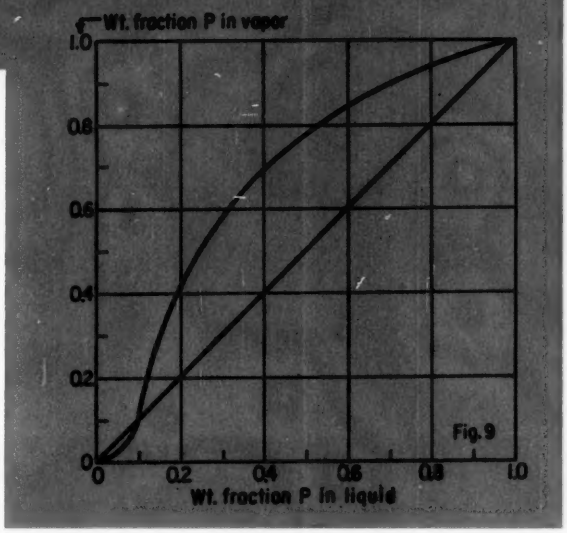
At equilibrium,

$$K' = k_2/k_3 = [E'][J]/[F][E] \quad (32)$$

Evaluate Postulates for Discrepancy



Equilibria Show Azeotrope



a trial-and-error choice from among all possible values of the coefficients involved is an impossibly large task —unless preliminary or approximate values can be obtained. From data developed in Figs. 6 and 7, Table IV presents a set of equations defining such preliminary values.

These equations, together with graphs similar to Figs. 6 and 7 for each temperature investigated in the batch experiments, lead to a preliminary log k vs. $1/T$ graph for each coefficient. If such calculations are carried out for a succession of time periods during the reaction, a successive, continued change in derived value of k is definite indication of discrepancies in experimental data or, more probably, in the assumed kinetic model.

Postulates for Discrepancy

The discrepancy noted previously in the amount of C remaining must now be resolved in order to precompute k_2 and k_3 for scheme 1. Several possibilities exist in addition to that of scheme 2. Two of these are:

1. Since analysis was carried out by distillation techniques, a high-boiling azeotrope could have been formed between E and P. Since E_{calc} was derived from P as analyzed, this could result in an undetected equivalent of E and P as here.

2. A subsidiary reaction between B and C may have occurred in parallel with that of Eq. 2. Thus,

$$C + B \rightarrow D + L \quad (33)$$

where D has a molecular weight of 200 and L of 100. Both must have boiling points in the range of the intermediate fraction I as before. The reaction coefficient will be designated as k_4.

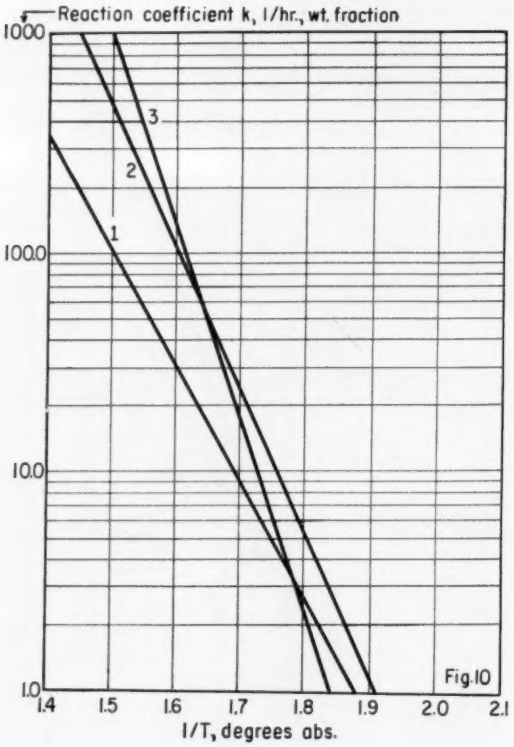
If we assume that an azeotrope exists, unaccounted-for material is all P and E. The pertinent curves of Fig. 6 must be redrawn, as shown in black in Fig. 8, by using the rule that $E = 2P'$. The second postulation can be similarly evaluated (shown in white, Fig. 8).

When Eq. 30 is used to calculate k_2 at several different intervals of time, consistent values are found throughout the reaction for both postulates. The unaccounted material is therefore not C. We have not, however, resolved the question of the nature of this material—whether it is $E + P$ in azeotropic form, or the new species $D + L$—and now mathematics fails us.

We must again go to the lab. Chemical research is asked to determine vapor-liquid equilibria for E and P. Their results in Fig. 9 show that a high-boiling azeotrope exists—a mixture of 90% E and 10% P. Thus, postulate 1 has been shown to be correct—if reaction scheme 1 is the final mechanism chosen.

We must now resolve the over-all reaction mechanism—if necessary by actually working out coefficients at each temperature and seeing if they are consistent. Often, a least-squares fit of analog computer results by each scheme is compared to the original experimental data. By closeness of fit, the most likely mechanism is picked.[2, 3]

Choose Coefficients by Computer



Additional experiments can be proposed to shed light. An experiment might determine whether or not B would react with I which was known to be free of C by complete reaction. What happened to B would resolve between schemes 1 and 2, or another scheme. Step c of scheme 2 is pertinent here; B must disappear for scheme 2 to apply.

It's probably easier to perform this experiment in the laboratory than to carry out all computer runs. The lab shows that step c does not exist.

The Final Choice

With the analog computer, the best values of k_1, k_2 and k_3 of scheme 1, shown in Fig. 10, are chosen by trial-and-error. (The temperature reciprocol is multiplied by 10^3 on the abscissa of Fig. 10.) **Fig. 11** shows (in white) what happens when k_1 is doubled, while k_2 and k_3 remain constant. This exercise, done similarly for each coefficient, shows sensitivity of the final (black) curves to changed k values.

That these k values are consistent over such a wide temperature range is ample evidence that scheme 1 is the *most probable* mechanism. Only direct chemical, not mathematical, proof can show it to be the *true* mechanism.

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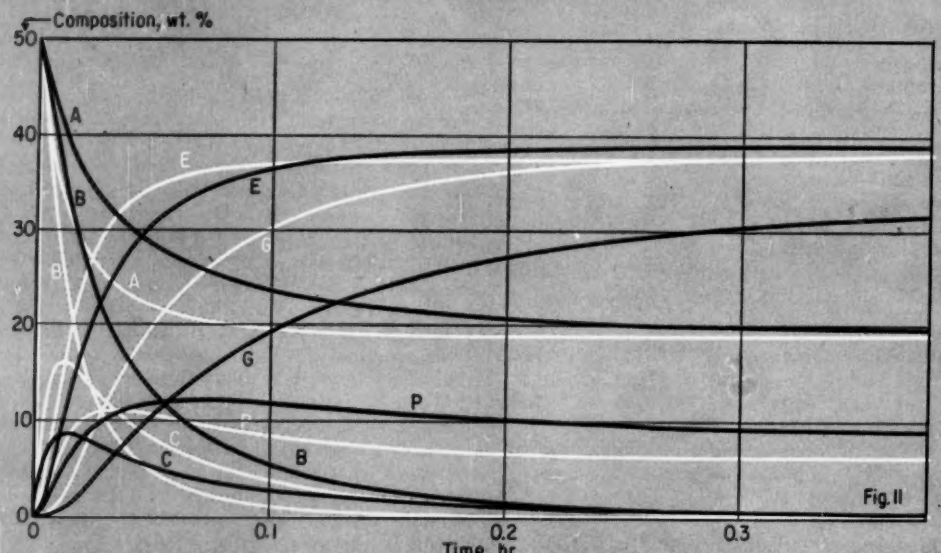
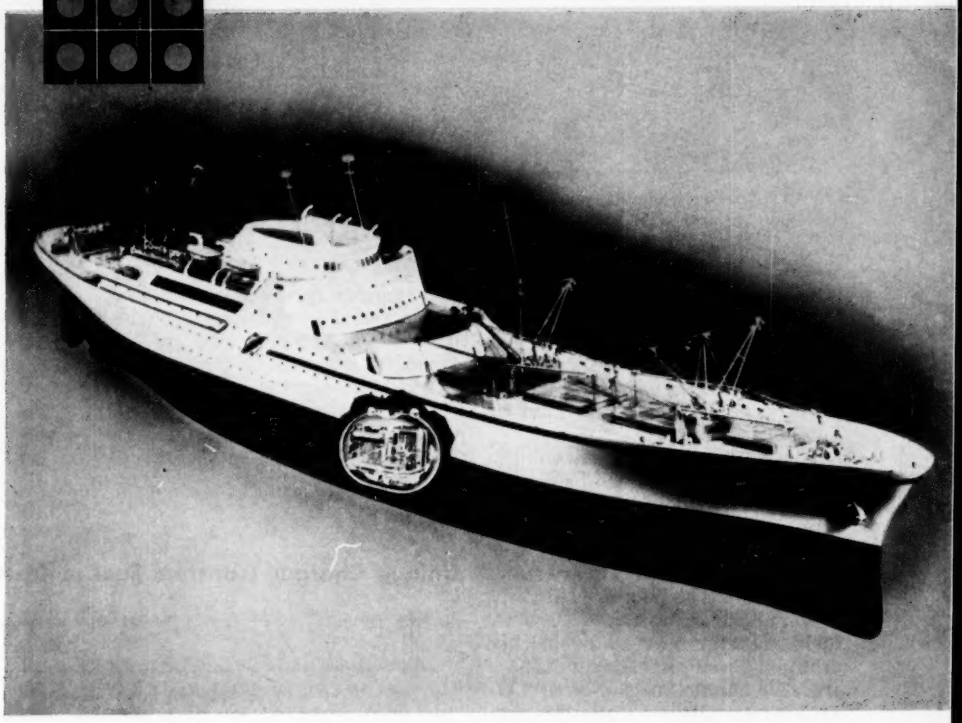
2. Box, G. E. P., Coutie, M. A., *Proc. Inst. of Electrical Engineers*, Pt. B, Suppl. 1, 103 (1956).
3. Box, G. E. P., Youle, P. V., *Biometrics*, **11**, 287-323 (1955).
4. Corrigan, T. E., Interpretation of Kinetic Data, *Chemical Engineering*, April—July, 1955.

Here Are Final Composition Curves at 180 F. for Chosen Reaction Scheme



Atomic Fuel Processing: Part V



OAK RIDGE: Home of THE bomb

Fuel from N.S. *Savannah*, first of the nuclear merchant marine, will be processed here along with many others.

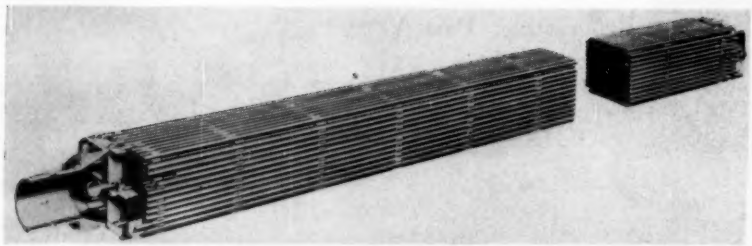
IF YOU have been reading the previous articles in this series, you should have by now a pretty good idea of the facilities required for processing nuclear power fuels. We have discussed receiving, storage, handling and processing at three AEC sites, but our emphasis has been, of necessity, rather general. It should be apparent to you by now that these facilities differ from one plant to another in detail but not in their basic approach to similar problems.

You know, for instance, that radioactive elements are stored and handled under water, that precautions to prevent critical accidents must be observed, and that highly active wastes require special attention. These problems are common to all the sites. The individual approaches to handling them may differ, but the underlying principles are the same.

In this article we would like to follow one particular fuel through the Oak Ridge facility, giving in greater technical detail the operations and chemical reactions involved. We will not give a once-over-lightly on the whole Oak Ridge plant as we did with the other sites except as descriptions of equipment and facilities are necessary for understanding the processing of this one fuel.

Oak Ridge National Laboratory (ORNL) was the original site of the Manhattan Project. Located in Tennessee, ORNL is the largest of the AEC's many facilities. Like all the other sites, Oak Ridge is also operated for the AEC by a contractor, Union Carbide Nuclear Co.

ORNL in the course of development and process demonstration will process some 13 power, test and



***SAVANNAH* fuel element consists of 164 stainless steel tubes containing uranium oxide pellets. Note inert end fittings which are removed before processing.**

research reactor fuels of all types ranging from full U^{235} enrichment to depleted (less than natural U^{235} enrichment). All of the fully enriched fuels are uranium-thorium mixtures containing a maximum of 7.6% uranium.

These 13 fuels are divided into seven classes according to composition and cladding. Class I fuels are stainless-steel clad with ThO_2-UO_2 cores. Class II are stainless clad with UO_2 cores. Class III are stainless clad with sodium-bonded cores of varying composition. Class IV fuels are aluminum-clad, enriched uranium-aluminum alloy. Class V are also aluminum clad with UO_2-ThO_2 cores. Class VI are Zircaloy-clad, uranium-zirconium alloy fuels and Class VII are liquid or slurry fuels from experimental homogeneous reactors. None of these fuels is yet being processed at ORNL; the first is scheduled for the spring of 1960.

We have chosen for our intensive review the fuel for the nuclear ship *Savannah*, a Class II fuel which is not scheduled for processing until 1964.

A complete N.S. *Savannah* core contains 32 fuel elements each of which is a bundle of 164 stainless steel tubes arranged in a square 8.7 in. on a side (see photo). Each element is 79½ in. long and weighs 189 lb.

Each fuel tube or rod is 0.5 in. in diameter and has a wall thickness of 0.035 in. The fuel in the rods is uranium oxide (UO_2) in pellet form made from pressed and sintered UO_2 powder slightly enriched to about 4.4% U^{235}. When the core is depleted after burn-up, the enrichment will be reduced to about 3.63%. For each gram of U^{235} burned, there will be 0.4 gm. of plutonium produced from the U^{238} in the original core. Only 1.06% of the material in the core is burned over the life of the core, which is estimated at about 3½ yr. The unburned fuel can be recovered.

Savannah is not yet operational. Oak Ridge has not yet built the facilities for processing *Savannah's* fuel. Indeed, they havn't decided exactly which process they will use and it is possible that major changes may be made between now and 1963. However, there are presently three processes under study, two of which are to be proved out in pilot plant on prototype *Savannah* fuel elements.

Two of the proposed processes are dissolution processes similar to those discussed in our previous articles. These are known as the Darex and Sulfex processes. In the first, aqua regia dissolves the entire element in one step. In the second, the Sulfex process, sulphuric acid dissolves the cladding and nitric acid dissolves the ceramic fuel pellets.

The third process under consideration is a chop-and-leach procedure in which the fuel elements are cut

Unique Charger Transfers Fuel to Dissolver

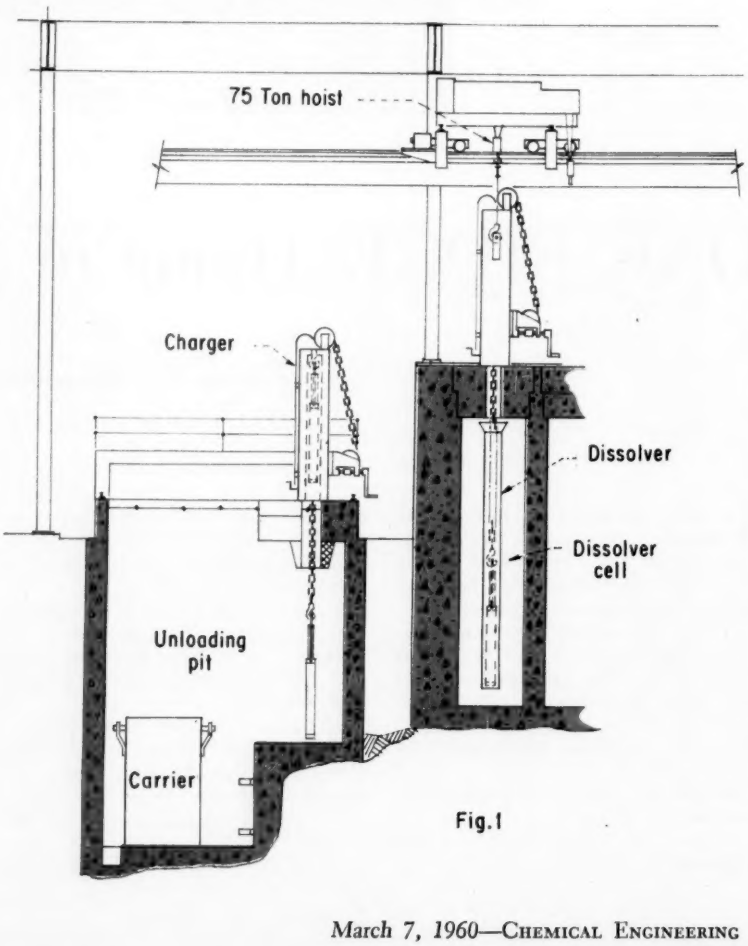


Fig. 1

Chloride Removal Biggest Part of Darex Dissolution, Requires 10 Hours for Completion

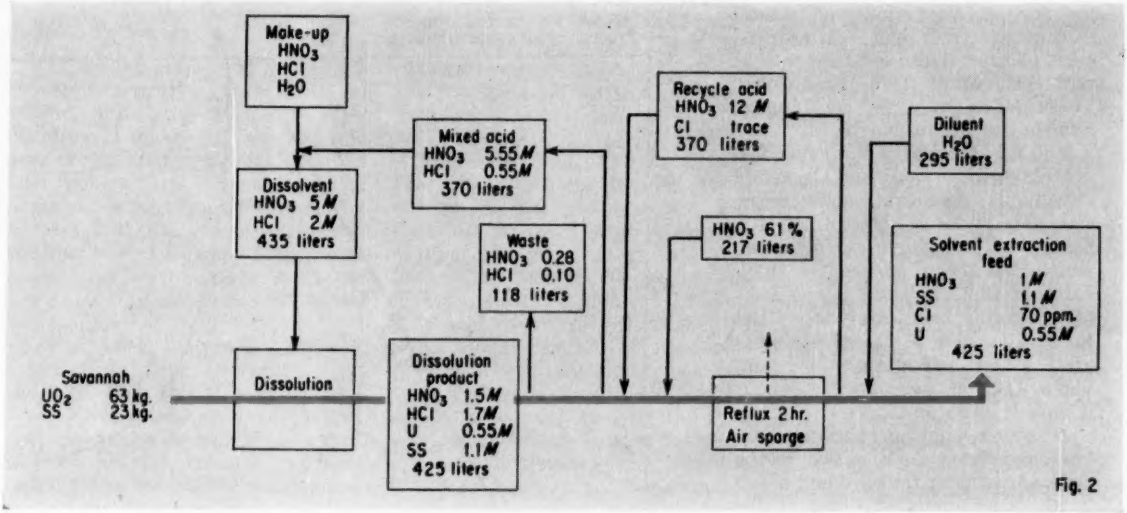


Fig. 2

into small pieces. Nitric acid then leaches out the uranium oxid fuel, leaving the insoluble cladding pieces behind for disposal.

Each of these systems has advantages and disadvantages. Total dissolution, as in the Darex process, simplifies operating problems, but the process yields a large volume of highly radioactive wastes. Selective dissolution, as in the Sulfex process, is operationally more complicated, but it yields a smaller volume of high-level waste and a larger volume of more easily disposable intermediate-level waste. Cut-and-leach is operationally the most difficult of the three, but if the method can be perfected, it will yield a smaller quantity of liquid wastes than any other process.

All three systems provide contaminated dissolver solutions of uranium and plutonium as feed to a Purex extraction system in which tributyl phosphate (TBP) in kerosene purifies and separates the solutions.

We will describe each of these processes in detail.

Handling Same as Other Sites

Spent fuel from *Savannah* shipped to ORNL will be unloaded, stored, mechanically processed and placed in charging casks by operations carried out entirely under water.

After the cover has been removed from the cask in which the fuel arrived at the site, a 1-ton crane will remove each fuel assembly from the cask and transport it to a storage area. If a fuel assembly should rupture during shipment, a simple canning device in the unloading pit will can it in aluminum before storage.

Fuel elements will be stored in containers placed side by side on storage rails that are 24 in. apart. Compartments filled with water are located between storage rails to prevent a critical accident caused by fuel in transit being brought between fuel in storage.

Normally, ORNL will perform mechanical operations on the fuel only after it has been stored and scheduled for processing. If scheduled for Darex or Sulfex processing, very little mechanical processing will be required on the *Savannah* fuel. An air-driven saw located 10 ft. underwater will cut off the inert end pieces of the fuel elements without disturbing the end caps on the individual fuel rods.

Particles produced by the saw will be collected on a tray under the saw and sent to a settling tank and filter in a stream of water. Remote manipulators will pick up the inert end pieces and drop them into underwater shielded collection containers for disposal when filled.

After removal of the end pieces, the saw moves out of the way, an ice-tong lifting device hooks onto one end of the fuel element, picks it up and places it in a simple wire frame holder for bottom loading into a charger cask. A 75-ton travelling crane picks up the loaded cask and transfers it to the dissolver where the same wire holder and attached chain are used to lower the element into the dissolver. See Fig. 1. The holder and chain are sacrificed during dissolution.

This is about all there is to mechanical processing of elements destined for the Darex or Sulfex processes. The proposed chop-and-leach scheme, however, requires a great deal more mechanical handling. We will discuss this process in detail later.

Darex Process

Under present planning at ORNL, half the *Savannah* fuel will be processed by the Darex process and half by the Sulfex process. The chop-and-leach process is still a research and development project.

The Darex process consists of three steps: (1) Dissolution with dilute aqua regia in titanium equipment; (2) chloride removal to pre-

vent corrosion of stainless steel in the solvent extraction and waste storage systems; and (3) adjustment of the nitrate solution to solvent extraction feed conditions. These steps may be continuous, semicontinuous or batch.

Fig. 2 is the Darex flowsheet for processing *Savannah* fuel. In semicontinuous operation, aqua regia composed of 5*M* HNO_3 and 2*M* HCl feeds continuously to the dissolver which has been charged with a batch of fuel. A batch is one complete element containing about 139 lb. of UO_2 and 51 lb. of stainless steel. The dissolution product, about 112 gal. per batch, is about 0.55 *M* in uranium.

Dissolver solution overflows continuously from the dissolver to the feed adjustment tank. When a full batch is accumulated, some of the mixed acid is distilled off to remove excess water. Then 12*M* recycle HNO_3, containing a trace of chloride, feeds continuously to the tank while mixed acid is continuously distilled for recycle to the dissolver. Batches of fresh 61% nitric acid are added and the solution refluxed with air sparging to volatize remaining chloride.

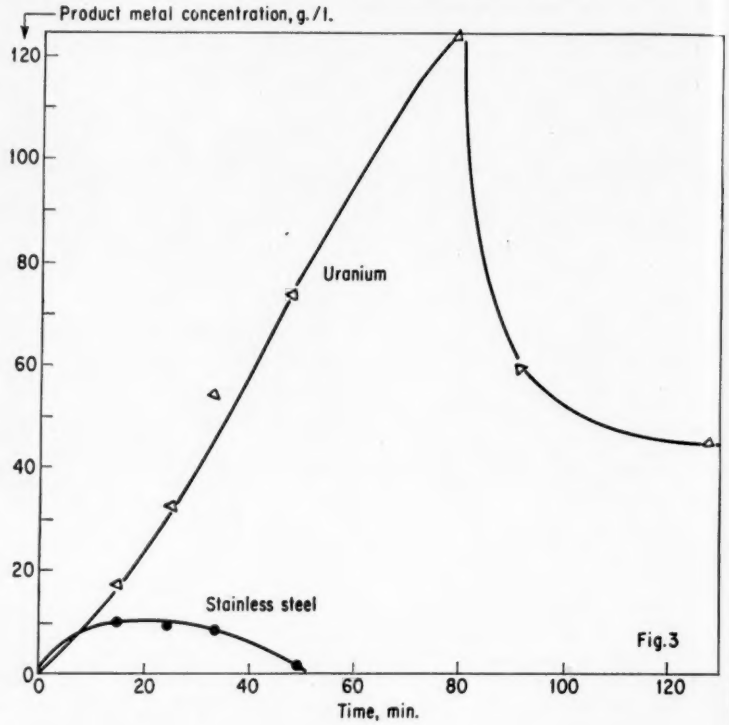
After the refluxing, which continues for about 2 hr., the acid is distilled and recovered for use in the next run. Only the addition of water to the dechlorided solution is needed to bring the metal and nitric acid concentrations to the level required for solvent extraction feed. Each batch yields about 112 gal. of feed which is 0.55 *M* in uranium, 1 *M* in nitric acid, 1.1 *M* in stainless steel and contains only 0.55 ppm. of chloride ion.

Total dissolution of an element takes about 4 hr., chloride removal requires another 10 hr.

In the continuous dissolving of a fuel such as *Savannah* fuel, there are three distinct periods of dissolution which can be seen in Fig. 3. In the first period, only stainless steel of known area dissolves. The dissolution rate of stainless steel in aqua regia increases directly with increasing feed-to-surface ratio while the concentration of dissolved metals decreases. The presence of UO_2 does not affect the dissolution rate of stainless steel.

In the second period, from the penetration of the cladding until its total dissolution, stainless steel and UO_2 dissolve simultaneously, with the area of either almost impossible to define. During this period, the dissolver effluent shows a buildup in uranium concentration to about 120g./l., while the stainless steel loading drops.

Metal Concentration vs. Time in Dissolver Product



The third period involves only dissolution of UO_2 after all the stainless steel has been dissolved. Stainless steel dissolution is complete in about 1 hr. and uranium dissolution is about 70% finished in 2 hr.

▶**Chloride Removal**—Equilibrium data for the system HNO_3-HCl-H_2O show that HCl is more volatile than nitric acid and that the relative volatility of the HCl increases with increasing nitric acid concentration. Though true equilibrium cannot exist under flowsheet conditions because of decomposition reactions, the trend persists sufficiently to be useful in the removal of chloride ion from the dissolver solution.

In the mixed acid recovery step, 12*M* nitric acid is added to the solution at the same rate as the mixed acid distills off. Chloride concentration rapidly reaches a maximum, then declines while the nitric acid concentration increases toward the feed acid level. After this step, refluxing at high nitric acid concentration with an air sparge removes remaining chloride. Then a single-stage batch distillation removes excess acid.

▶**Fission Products**—Experiments with a prototype *Savannah*-type fuel pin irradiated to 1,000 megawatt-days/ton (Mwd./t.) and decayed for 4 mo. indicated that more than 99% of the fission products remained in the dissolver solution. ORNL expected one of these elements, ruthenium, to become volatile at acidities of 8 to 11*M*, but only 0.37% volatilized and condensed with the recycle acids. This, of course, means that it stayed in the system instead of going off with the off-gases. Such other fission products as did not remain in the final dissolver solution precipitated on the equipment surfaces. Because the amount of active material trapped in the off-gas scrubbers and filters was so low, the Darex

process does not present a serious off-gas disposal problem.

Sulfex Process

The Sulfex process (Fig. 4) is a two-step selective dissolution in which first the stainless steel cladding is dissolved, removed and sent to waste storage and then the UO_2 pellets are dissolved. The principal advantage of the Sulfex process over the Darex process is the decrease in volume of high-level radioactive wastes since the separated cladding material solution can be stored as intermediate level waste in cheaper tanks. However, experiments have shown that irradiated fuel pellets will disintegrate which causes losses of the fuel material to the decladding solution. If these losses eventually prove to be too great, the Sulfex process may not appear so attractive.

This process is also semicontinuous. A 200% excess of boiling 6*M* sulfuric acid initiates dissolution of the cladding. However, to reduce corrosion of the Ni-O-Nel equipment, the solution will be diluted and the dissolution continued with 4*M* acid. The solution has to be diluted to 4*M* eventually to prevent precipitation of stainless steel sulfates when cooled to room temperature. Decladding takes about 3 hr.

10*M* nitric acid dissolves the declad fuel pellets in the same dissolver after removal of the cladding solution to waste. Addition of water to the core solution adjusts the uranium concentration to 1.3 *M* and the acidity to 3*M* nitric acid. There remains also a trace of sulfuric acid.

There are other disadvantages to the Sulfex process besides losses due to fracture of the pellets. Decladding produces large quantities of hydrogen which is an explosion hazard and taxes the off-gas system. Use of the same equipment for cladding and core dissolution leads to cross contamination of the solutions with resultant nitrate passivation of the stainless steel cladding and sulfate inhibition of the core dissolution (this reaction takes 20 hr. for completion.) As little as 0.01*M* nitrate can passivate unoxidized stainless steel in 6*M* sulfuric acid. If the stainless is already oxidized, the maximum tolerable nitrate concentration is 0.0005*M*.

Another problem with Sulfex is the recovery of UO_2 fines from the decladding solution.

Chop-and-Leach

The main attractions of the chop-and-leach method are the reduction in volume of liquid wastes, increase in capacity of the processing plant and the possibility of dissolving the declad fuel in stainless steel equipment. ORNL is trying to establish the feasibility of this method of processing.

In principle, the chop-and-leach method is quite simple. In a shielded dry cave (as opposed to normal under-water processing) a specially designed shear will chop bundles of fuel rods into small pieces. Optimum size of the cut pieces has not been determined. The smaller the pieces, the more efficient the leaching action. However, smaller pieces result in greater dislodgement of the fuel pellets from the interior of the tube and increased fracture of the pellets. These effects increase particulate losses and contamination problems.

Chopped pieces will drop into a wire mesh bucket (1,000 micron screen) which is inside an aluminum foil bucket. When full, a slide valve closes, isolating the bucket from the shear. Water sprays wash all surfaces and wet the fuel in the bucket to prevent air contamination. The bucket then goes to the leacher where nitric acid catalyzed with mercuric nitrate dissolves the aluminum foil and allows the acid to attack the fuel. Stainless steel fines that escape through the mesh bucket leave the leacher with the

Sulfex Process Requires Two Steps; Both Dissolutions Are Done in Same Ni-O-Nel Equipment

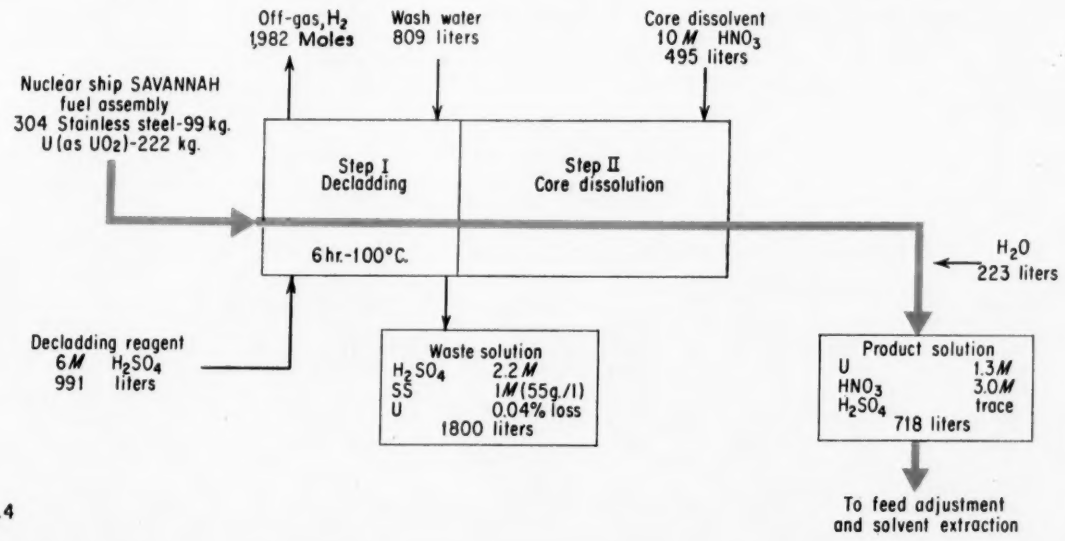


Fig. 4

Flowsheet Shows One Cycle of Darex-Purex Extraction

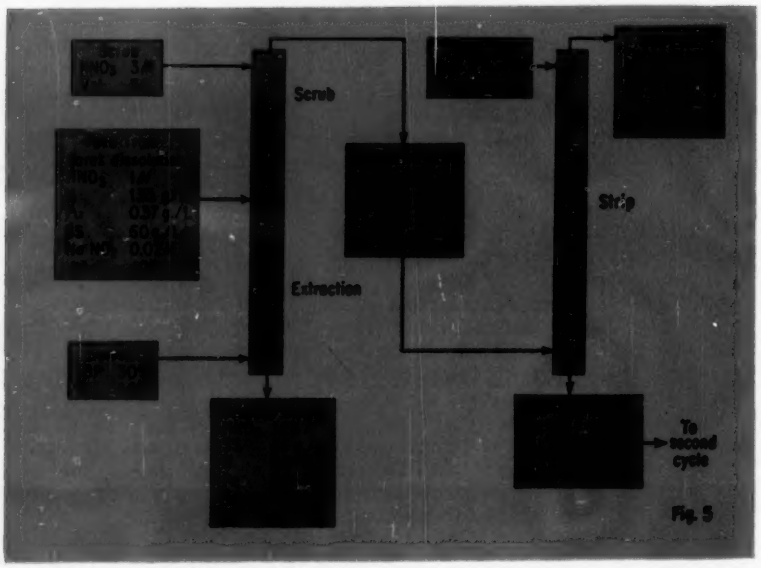


Fig. 5

uranyl nitrate solution and are removed in a clarification step.

After leaching is completed, the mesh bucket containing the empty stainless pieces is removed and disposed of.

Solvent Extraction

ORNL will use the Purex extraction process for purification of the dissolver solutions and separation of the uranium and plutonium. Details of the process, however, will vary depending on the head-end process because of the large quantity of stainless steel in the Darex solution which is not present in the Sulfex solution.

Fig. 5 shows one cycle of the Darex-Purex extraction process.

Addition of nitrite to the dissolver solution converts the plutonium to Pu(IV), making it selectively soluble in the solvent, tributyl phosphate (TBP.) Aqueous plutonium and uranium are separated from iron, chromium, nickel and fission products by contact with 30% TBP in kerosene in the extraction section of the pulsed column extractor. They are further separated in the scrub section where the solvent is backwashed with 3*M* nitric acid. Loaded solvent then goes to the strip section where it is stripped with 0.01*M* nitric acid. The again aqueous stream is concentrated by evaporation, treated with nitric acid and nitrite, and extracted through a second cycle. Plutonium and uranium are separated from one another in a third cycle. When required, these separated streams can be purified still further in additional purification cycles.

More than 99.9% of the fission products and stainless steel leave the system in the first-cycle aqueous waste stream. A total of 6 to 8 stages is required to accomplish this fission products decontamination.

Purex extraction of Sulfex solutions is little different from the above. As mentioned, there is no stainless steel and the acid concentrations in the feed and scrub are different. The same will apply to extraction of chop-and-leach solutions.

Waste Storage

Processing of the *Savannah* fuel will produce about 8,500 gal. of high-level waste and 50,000 gal. of intermediate waste. The high-level wastes, after 6 mo. storage, will be producing 156,000 Btu./hr. of decay heat. After 18 mo., heat production will still be 72,800 Btu./hr.

The high-level wastes will be stored in cooled stainless steel tanks without neutralization. Water circulating through internal coils will cool the tanks. Design heat removal capacity will be 2.5×10^6 Btu./hr. with the waste at 160 F. and inlet water at 90 F.

Intermediate wastes do not generate enough heat to require cooling. They will be neutralized, concentrated by evaporation and stored in concrete or mild-steel tanks.

A significant fraction of the high-level wastes may go to the ORNL Fission Product Pilot Plant (F3P) for radioisotope separation and recovery instead of directly to evaporation and storage. Isotope recovery would decrease the waste-heat removal load, but would not decrease the total waste volume since the effluent from the F3P would be intermediate waste. Indeed, the F3P may actually increase the waste volumes since additional chemicals are added in the recovery process.

This completes our 28-p. series on nuclear fuel processing as planned under the AEC's interim fuel processing program. It is not nearly so detailed or extensive as we, or you, might like. But we hope we have given you some insight into the scope, the processes and the problems in this new field for chemical engineers.

ACKNOWLEDGEMENTS

This fifth and final article of the series is based on the following papers presented by members of the Oak Ridge staff at the AEC's symposium on Chemical Processing of Irradiated Fuels from Power, Test and Research Reactors, held at Richland, Wash., Oct. 20-21, 1959.

The papers are: "Fuel Processing Facilities at ORNL," by H. E. Goeller; "Mechanical Processing of Spent Power Reactor Fuel at ORNL," by C. D. Watson, J. B. Adams, G. K. Ellis, G. A. West, F. L. Hannon, W. F. Schaffer and B. B. Klima; "Chemical Processing of Power and Research Reactor Fuels at ORNL," by R. E. Blanco, L. M. Ferris, J. R. Flanary, F. G. Kitts, R. H. Rainey and J. T. Roberts; "Special Problems in Chemical Processing at ORNL," by A. R. Irvine; and "Accountability of Special Nuclear Material at ORNL," by W. T. McDuffee.

Complete proceedings of the symposium are available from the Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Ask for Bulletin TID 7583.

Choosing Drivers for Centrifugal Compressors

You must consider

- Operating limitations such as
  - Utilities available
  - Plant steam balance
  - Need for compressor speed changes
  - Need for spare or multiple units
  - Size of compressor to be driven
- Installed cost of driver
- Operating and maintenance costs

FRED L. GILLETT, Senior Chemical Engineer, C. F. Braun & Co., Alhambra, Calif.

THERE are, in general use today, many types of drivers for centrifugal compressors. Steam turbines and electric motors are used in the great majority of cases, but one of the other types may be exactly the right machine under certain circumstances, and hence must not be overlooked. The other types include combusion gas turbines, gas engines and expansion gas turbines.

Before we can discuss driver selection, we should take a look at the compressor. It is not always possible to decide immediately that a centrifugal is best for a given service, then later select the driver. Usually we must select the compressor type and driver type concurrently, because they are interdependent.

As an example, let's say we are selecting equipment for the following conditions: Size of about 2,500 hp., for continuous service. A utility cost structure that dictates use of fuel gas as the power source. A head requirement such as to call for a multistage centrifugal.

Presented Dec. 3, 1959, before the Annual Meeting of ASME at Atlantic City, N. J.

Our first thought might well be to use a single centrifugal. But we run up against a real problem when it comes to the driver. The size is too small for a combustion gas turbine. But, if we select gas engines, we must include spares to permit engine maintenance. The lowest cost selection here would be three gas-engine-drive reciprocators, each sized for one-half the total load.

Here are a few limitations and rules of thumb for centrifugals. An awareness of these rules will help the engineer making the driver study to spot a situation that calls for re-evaluation of the compressor selection.

• The practical lower limit on centrifugal capacity is about 500 cfm. actual discharge volume.

• Centrifugals are subject to unstable operation below about 60% of design flow. Lower turndown can be accomplished, of course, by recycling gas. However, this is usually not economical except where recycling is required for only a small part of the time. Suction throttling may also be used to increase the range of stable operation, but at some sacrifice in efficiency for part-load operation.

• Centrifugals develop between 8,000 and 10,000 ft. of head per stage. Single-stage machines are relatively inexpensive as compared with multistage machines. Maximum number of stages available in standard machines is from three to ten, depending upon size.

• Head developed by centrifugals depends upon the molecular weight and inlet temperature of the gas. Hence, centrifugals cannot be used where great fluctuations in molecular weight or inlet temperature are expected.

• The economic breakpoint between centrifugals and reciprocating compressors is about 1,500 hp. for multistage centrifugals, and about 500 hp. for single-stage machines. These limits, however, must be used with caution because there are many borderline cases. Reciprocators are generally the least expensive type for horsepower much below these limits. For horsepowers substantially above these limits, the centrifugals look best, provided the discharge volume and head requirements are in the centrifugal range.

• Reliability of centrifugals is such that spare machines are sel-

dom used. Frequently, the combination of long runs and the need for valve maintenance will require providing spares when reciprocators are used. This consideration may have a marked effect on the selection of compressor type—particularly when the horsepower is close to the breakpoints mentioned above.

Once we have decided that a centrifugal is best, we may proceed with driver selection. Many factors influence this selection. We can group these factors into three main categories: (1) Operating limitations; (2) installed cost; and (3) operating and maintenance costs. We shall define and evaluate these factors and then outline a procedure for the selection of the proper driver for a given service. To illustrate the effect of the major elements, we shall examine a typical economic comparison. But before discussing the effect of the various factors on driver selection, let's explore the fields of application and the limitations of each driver type.

Steam turbines are one of the most important drivers. They are ideally suited to this service for several reasons. In the size range of centrifugal compressors, turbines are one of the least expensive types. They are efficient from the standpoint of conversion of thermal energy into mechanical energy. They lend themselves beautifully to speed control by which compressor suction pressure, discharge pressure, or process-gas flow are indirectly controlled. And they rate high on the list for reliability and maintenance costs. They may be used in continuous service where runs of from one to three years are contemplated. They are limited, of course, to use in plants where steam is available, or can be made available at reasonable cost.

Our other major type of driver is the electric motor. Although motors are somewhat more costly than steam turbines, the total installed cost of a motor-driven compressor will generally be lower than a steam-drive installation if the turbine is of the condensing type. The cost of the surface condenser and cooling-water facilities tips the scales here.

Motors are second to none when it comes to reliability and low maintenance costs. On the debit side, they usually require speed-increasing gears because of high compressor speeds. And because a motor is a constant-speed machine, it may be necessary to use a variable-speed hydraulic coupling to effect control of the process variable. Use of variable-inlet guide vanes on the compressor, suction dampers or discharge-to-suction bypassing, are less expensive ways out. Hydraulic couplings are costly, hence are justified only where extended periods of part-load operation are expected.

Combustion gas turbines have one big advantage—they burn fuel gas directly. So if fuel gas is the least expensive source of power or the only one available, give these machines a close look. Although relatively new in the compressor-driver field, they have proven themselves to be reliable, with maintenance costs of the same order of magnitude as steam turbines. Gas turbines have three drawbacks. They are very expensive. Their overall thermal efficiency is low. And they come in only a few sizes. Sizes of American-made machines include one at 1,200 hp., one at 3,500 hp., one at 5,300 hp., then a number in larger sizes up to 30,000 hp.

There are three sets of circumstances where combustion gas turbines should be considered: (1) Low fuel gas cost, plus a plant deficiency in moderate-pressure steam. A waste-heat boiler to recover heat in the exhaust gas may be employed here. Credit for the steam produced will offset the high first cost. (2) Conditions where the turbine can serve double duty by integration with the process scheme. Here the turbine is used as a hot-gas generator, or as a source of compressed air which is bled off the air compressor end of the machine. Finally (3) situations such as isolated compressor stations where gas is the only source of power and water is in short supply. Incidentally, this last has been the major gas turbine application.

Another type of driver which burns fuel gas directly is the gas engine. These machines, compared with gas turbines, are less expensive, have higher thermal efficiencies, and are available in a complete range of sizes up to 5,000 hp. But they require the use of speed increasers because of their low speed. Although they have good reliability, they must be shut down periodically for maintenance. They are more costly than either steam turbines or motors, so gas engines are seldom used to drive centrifugals in plants where steam and electric power are available. Their principal application is in gas pipeline compressor plants, where they are used to drive large single-stage centrifugals. This particular combination is less expensive than gas-engine reciprocators of the same size.

The last type of driver to consider is the expansion gas turbine. These machines are similar to steam turbines in both design and cost. They use a process-gas stream as the source of energy. They are seldom used as compressor drives because high-pressure gas is not often available in sufficient quantity. They are used mainly in plants employing low-temperature processes, where a gas stream is expanded through the turbine in order to refrigerate that stream. Although this driver is special, it is worth keeping in mind, for it is a real money-saver.

Now that we have considered each type of driver individually, let us compare them in terms of the major factors which determine their selection. Our first category is operating limitations. Probably the most important of these is the plant steam balance. If you can fit a back-pressure steam turbine into the picture, by all means do so. It is ideal from all standpoints, including cost. Often it is possible to adjust the steam generation pressure to effect a good steam balance.

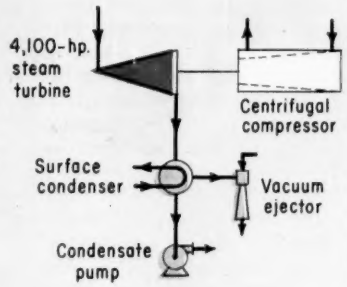
Another operating limitation involves the nature of the compression service. We are concerned here with the magnitude and frequency of fluctuations in both process gas flow and molecular weight. Both affect the degree of speed change required. This makes no difference for a steam turbine. But it determines the choice of speed-control equipment and therefore the cost of a motor-driven installation. And it affects the cost of a combustion gas turbine. It is an interesting fact that a compressor driven by a gas turbine of the single-shaft type will stall if the speed drops below a certain point. The more expensive two-shaft type is immune to this problem.

Still another operating limitation which concerns us is the considera-

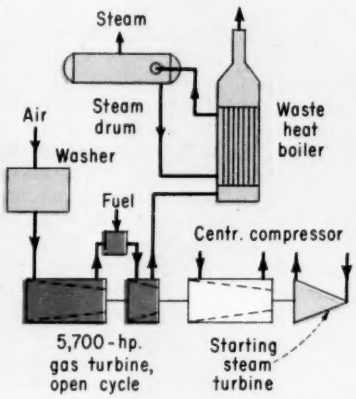
Economic Comparison of Drivers for a Centrifugal Compressor

1—Steam Turbine Drive

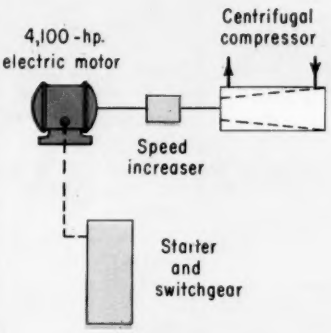
(Alternate is use of two duplicate units half the size of single unit.)



2—Gas Turbine Drive



3—Electric Motor Drive



Equipment	1—Steam Turbine Drive Single	1—Steam Turbine Drive Multiple	2—Gas Turbine Drive	3—Motor Drive
Compressor	1 @ 4,100 hp.	2 @ 2,100 hp.	1 @ 4,100 hp.	1 @ 4,100 hp
Driver	steam turbine, 110 psig. to cond.	steam turbine, 110 psig. to cond.	Single-shaft, simple-cycle gas turbine	electric motor 13,800-v., TEIGF
Major auxiliaries	Surface condenser Condensate pump Vacuum ejectors	Surface condenser Condensate pump Vacuum ejectors	Waste-heat boiler Steam drum Inlet air washer Air duct, stack	Speed increaser Switchgear Starters
Investment costs				
Compressors	$115,000	$170,000	$115,000	$115,000
Drivers and gears	80,000	120,000	345,000	105,000
Auxiliaries and installation	280,000	370,000	540,000	195,000
Service facilities				
Steam gen. @ $1.5/lb./hr.	91,000	94,000	52,000 Cr	.....
Water cooling @ $15/gpm.	60,000	62,000	14,000	11,000
Total investment	630,000	820,000	960,000	430,000
Utilities requirements				
Steam, lb./hr.	61,000	64,000	35,000 Cr	.....
Fuel gas, scfh	.....	.....	78,000	.....
Power, kw.	10	10	60	4,100
Cooling water, gpm.	4,000	4,200	930	750
Operating costs, 2½ yr.				
Alternate (a), Steam @ 35¢/M lb.	$440,000	$465,000	$250,000 Cr	.....
Fuel gas @ 10¢/M scf.	.....	.....	170,000	.....
Power @ 9 mils/kwh.	2,000	2,000	11,000	$765,000
Cooling water @ 1¢/M gal.	50,000	52,000	12,000	9,000
Maintenance	16,000	16,000	21,000	11,000
Oper. cost total, 2½ yr. (a)	508,000	535,000	36,000 Cr	785,000
Alternate (b) same except				
Steam @ 20¢/M lb.	$250,000	$260,000	$143,000 Cr	.....
Fuel gas @ 20¢/M scf.	.....	.....	340,000	.....
Oper. cost total, 2½ yr. (b)	318,000	330,000	241,000	$785,000
Alternate (c) same except				
Power @ 5 mils/kwh.	$1,000	$1,000	$6,000	$425,000
Fuel gas @ 20¢/M scf.	.....	.....	340,000	.....
Oper. cost total, 2½ yr. (c)	507,000	534,000	129,000	445,000
Total inv. plus 2½ yr. oper. cost				
Alternate (a)	$1,140,000	$1,360,000	$920,000	$1,220,000
Alternate (b)	950,000	1,150,000	1,200,000	1,220,000
Alternate (c)	1,140,000	1,350,000	1,090,000	870,000

tion of spare or multiple units. It is difficult to set down any rules here because many factors come into play—reliability of the utility or power source, reliability of the driver, length of run, consequences and cost of both emergency and scheduled shutdowns, to name a few. The effect on driver selection is primarily that of cost and driver availability. For example, the decision to use multiple units may rule out gas turbines because of an unavailable size. Or any decision to provide a spare for a machine only if a specific type of driver is used, would probably rule that driver out on account of cost.

The second major factor to be considered in driver selection is that of capital cost. Here are some approximate figures. Steam turbines will run between $20 and $35 per horsepower, depending on size and steam conditions. Motor costs vary between $25 and $40 per horsepower, depending upon size, voltage, and enclosure type. These costs include a gear unit. Add about $15 per horsepower if a hydraulic coupling is needed. Combustion gas turbines cost between $75 and $95 per horsepower for the single-shaft variety, with an additional $15 per horsepower for the two-shaft type. Gas engines will hit close to $80 per horsepower, including the gear unit.

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The third major factor is operating and maintenance costs. Utility costs vary widely, of course. And maintenance cost, too, will vary—but to a lesser degree. It is important to pin all of these costs down before attempting to select the driver, as they will have a great bearing on the selection.

Our tabulation shows an economic comparison of several drivers for a centrifugal gas compressor. Although the numbers have been changed to bring out certain points, this tabulation is based on an actual detailed study made for a process gas service in an oil refinery. Neither the capital costs nor the utility costs shown in the table should be used as such in making your own driver study, but must be developed specifically for each project. The figures shown are typical, however, and indicate what you may expect to find.

An analysis of the operating limitations led to the choice of the specific driver type and auxiliaries considered in this comparison. Here is a brief rundown: The steam balance would not permit use of a back-pressure turbine, so condensing steam turbines were chosen. Expected changes in molecular weight and flow rate were low in magnitude. For this reason, the gas turbine in the comparison was of the single-shaft type. And the motor installation studied was based on constant-speed operation to avoid the cost of a hydraulic coupling.

The table points out those things that should be included in a detailed study. The entry for Auxiliaries and Installation requires explanation. This includes all auxiliaries shown, together with: buildings (here the compressors are mounted on an elevated platform in a steel frame building with Transite roof and partial sides), foundations, electrical wiring and gear, piping and valves, instruments, field labor, and other proratable expense.

As you can see, the table uses three sets of utility costs to show their effect on driver selection. Again, these figures are fictitious but typical of those one might expect to find in different locations in the U. S. For simplicity, we have added the operating costs for 2½ yr. to the total investment costs to give figures for comparison. (This is roughly equivalent to a 5-year payout, after taxes, on the incremental investment, without taking depreciation into account.) A more accurate method would be to determine the individual depreciation rates for each part of the capital cost. All costs would then be expressed on an annual basis, and the cash flow and payout periods on the incremental investment computed.

The table also shows in Case I what the effect on cost is of using multiple units. It is significant that if use of multiple units had been a requirement, combustion gas turbines would have been ruled out at the outset, because machines of this size are not available.

In concluding this discussion, it is worthwhile to review the steps the engineer must take in selecting a driver. First, he must establish to a reasonable degree of certainty that a centrifugal compressor is the proper machine for the job. This is done by computing discharge volume, head and horsepower. By applying the rules of thumb mentioned earlier, he can get a pretty good idea whether the decision is correct. Then he will review the operating limitations: What utilities are available? How many machines will be needed? What equipment will be needed for speed or capacity control? And what type of turbine should be used—condensing or back-pressure?

Determining the utility costs is his next step. These figures should be as accurate as possible, since an error here can seriously affect the selection. With this information and with some estimated cost figures, a rough comparison can be made. Installation costs and costs of major auxiliaries such as surface condensers must not be overlooked. For this first pass, the engineer will not go too far wrong if he doubles the machinery costs to allow for installation costs. Then, if the differences in total evaluated costs are large, he will have his selection without further ado. But, if small differences point toward a more detailed comparison, the intangibles should be re-examined. It may be that one of the drivers considered will offer sufficient advantages in intangibles to offset any small differences that might show up as a result of a detailed comparison.

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English	Technical Mathematics
Technical Mathematics	Slide-rule Instruction
Spelling	Engineering Terminology II
Personality Development	Inorganic Chemistry
	Personality Development

Second Year

Junior Semester	Senior Semester
Engineering Shorthand	Engineering Shorthand
Engineering Dictation	Engineering Dictation
Engineering Transcription	Engineering Transcription
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THEORETICAL chemistry is

Secretaries Who Talk Your Language

Graduates of this two-year business training college glide through technical terminology and engineering fundamentals; a boon to the busy chemical engineer who needs an aide.

John McDonnell and Sondra Koval are a chemical engineering team.

He's a 1946 B. Ch. E. graduate of the University of Oklahoma. As director of commercial plans in Gulf Oil's petrochemicals department in Pittsburgh, McDonnell is chiefly engaged in planning for future ventures by Gulf into the chemical field. Also, he maintains close liaison with the petrochemicals sales staff—many of whom are chemical engineers—now headquartered in New York.

Sondra is a graduate of Business Training College (BTC) in Pittsburgh, where she completed the special two-year engineering secretarial course. She plays an important part in this liaison work by daily circulation of complicated technical

taught to all degree candidates.

PRACTICAL lab work demonstrates step-by-step engineering procedures.

SLIDE RULE, typewriter, ability and personality are Sondra Koval's indispensable working tools as a chemical engineering secretary.

production reports. In fact, because of her unique training, she is able to handle this special chore in the absence of her boss.

McDonnell describes Sondra as an extremely capable person, especially in the fields of taking dictation and the handling of engineering terminology. Undoubtedly, this can be credited directly to her use of a chemical engineering shorthand devised by Dean Phyllis E. Davis of BTC. A listing of some of the other special training that Sondra has completed is given in the table on p. 148.

► **An Interesting Boss**—Sondra says that her boss is calm, and thoughtful. She says that she has never seen him excited and, although he works extremely diligently, he plans his office activities so that he never pushes her too hard.

Many of these characteristics, she thinks, are because most engineers need to be well organized and methodical. Sondra has compared notes with many of her girl friends whose supervisors are not engineers, and she believes her engineer-type boss is much more interesting to work for than those of her girl friends.

► **Engineer Minded** — On the personal side, Sondra is a very attractive blond; age: 21. Her interest in engineering has carried over into her extra-curricular activities also.

Recently, at a dance, she met a young mechanical engineer from Carnegie Tech. He became especially interested in her because she could understand his language, and converse on engineering subjects as a result of being an engineering secretary.

"After we are married," she says, "he wants me to be his secretary."

Industry acceptance of the concept of an "engineering secretary" is burgeoning, according to George Butterly, director of public relations for BTC. The entire 1959 class located jobs quickly, many long before graduation.

INTELLECT

. . . *Is Not Mortgaged*

If upheld by higher courts, a recent decision by Federal District Judge Alexander Holtzoff will have widespread significance for all engineers and their employers.

Case involved the right of Vice Admiral Hyman G. Rickover, as a public official, to retain his speeches on nuclear power and education under his personal copyright. Judge Holtzoff ruled:

"No one sells or mortgages all the products of his brain to his employer by the mere fact of his employment. The officer or employee still remains a free agent. His intellectual products are his own, and do not automatically become the property of the Government."

ENGINEERS

. . . *How Many Are There?*

American business employed about 780,000 scientists and engineers in Jan. 1959, and 35% of the total were engaged in research and development. So states the latest available estimate by National Science Foundation.

Engineering employment in industry increased from 605,000 in Jan. 1958 to 630,000 in Jan. 1959. NSF estimates that engineers in industry represent two-thirds of the national total.

Therefore, how many engineers? More than 900,000 today.

NEW SCHOOLS FOR

. . . *Chemical Engineers*

Add these three to your list of departments of chemical engineering:

- Rutgers College of Engineering, New Brunswick, N. J. Undergraduate degree to be offered for the first time.
- Stevens Institute of Technology, Hoboken, N. J. New graduate program leading to a doctor of science degree. Note, however, the lack of an undergraduate program.
- Polytechnic Institute of Brooklyn, Farmingdale, L. I., N. Y. New graduate campus.

Progress Report...

CELLOSIZE
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One of the most adaptable of the synthetic water-soluble gums is CELLOSIZE hydroxyethyl cellulose. This white, fluffy-to-granular powder is non-ionic and readily soluble in hot or cold water. The various grades have many applications in a wide variety of industries.

Paint-Making Timesaver...

In latex paints, CELLOSIZE WP-4400 has high thickening power at low concentrations. It is also soluble and non-gelling in water at temperatures up to boiling. You can add WP-4400 to pigment grinds and still obtain instant color development during hot let-down with phthalo colors. The ease of solution and low-foaming characteristics of WP-4400 speed preparation of latex paints.

Latexes thickened with WP-4400 exhibit good shelf life, stability to pH variations, and freeze-thaw resistance. Clean, bright colors are assured, with little tendency to form pinholes in the film. Other desirable properties are viscosity stability, excellent flow-out, and good scrub resistance.

More Paper Strength...

Preliminary tests show that paper products such as towels and tissues gain in wet strength, absorbency and softness when treated with CELLOSIZE HEC and glyoxal. This also suggests evaluation with non-woven fabrics. Coatings made from HEC are impervious to both liquid and vapor forms of oils, greases, and most solvents. Fiber containers lined with a film made from CELLOSIZE HEC have held lubricating oil, ethylene dichloride, and other hydrophobic solvents without leakage for two years.

Paper sized with CELLOSIZE HEC has excellent gloss and hold-out for oil-based inks, varnishes, and lacquers. Only about 0.1 to 0.5 pounds of the gum per 1000 sq. ft. of paper is usually required for this purpose. Cooling the paper to prevent gelation is not needed.

CELLOSIZE HEC used as a textile finishing size contributes stiffness with less solids, better heat stability, and easier preparation than the usual starches. Soil removal from ironed fabrics is also greatly facilitated.

Hydroxyethyl cellulose is being used in textile emulsions where solution stability and good dilution stability are desired.

Smoother Cosmetics...

As a binder, thickener, stabilizer, and film-former in cosmetic preparations, CELLOSIZE HEC is unexcelled. Its ease of solution and efficient thickening ability are time-savers in formulating shampoos, creams, and lotions. Tolerance for concentrated aluminum salts makes HEC ideal for deodorant creams, lotions, and sticks. The chemist may compound with either anionic or cationic additives without coagulating the system. Lubricity and pleasant "mouth feel" are imparted by CELLOSIZE HEC to many pharmaceutical preparations.

Ceramic Color-Dispersant...

In dry-molding ceramics, this CARBIDE non-ionic gum is a useful binder and water-retaining agent. It produces powders that contain enough moisture to be plastic under pressure.

Luminescent pigments, such as used for coating instrument dials, and other ceramic colors are effectively dispersed with CELLOSIZE HEC. The non-ionic serves as both dispersant and binder for the pigment-glass flock material sprayed on colored glassware and later fired.

There are many more applications for CELLOSIZE HEC. Its high thickening efficiency and compatibility with borates facilitate the formulation of adhesives. Coating rubber or plastic goods with a solution containing CELLOSIZE HEC prevents sticking and protects them from marring during processing. Agricultural sprays, dusts, and wettable powders can be efficiently prepared with CELLOSIZE HEC. Its colloidal action is of value in electroplating solutions, giving a brighter finish to metal, particularly in cadmium plating.

More Information Available...

Further information on CELLOSIZE HEC—properties, where and how to use it, plus other valuable data—can be obtained from a Technical Representative in any CARBIDE office. For a technical bulletin listing many suggested applications, please mail the coupon.

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CE COST FILE

No. 26: Unit Construction Costs; Warehouses

A. R. Sellers, Phillips Petroleum Co., Bartlesville, Okla.

Use Unit Costs for Warehouse Estimates

The following tabulation, continued from Cost File 25, Feb. 8, permits rapid calculation of a large variety of warehouses. Figures in the last two columns summarize cost per square foot for each item in two warehouse sizes.

Data are based on rates at Tulsa, Okla., Oct., 1959 and include profit and overhead. They assume 14-ft. ceilings. Two examples are worked out here to show how the unit costs are applied to specific building plans.

	Unit Cost	Cost, $/Sq. Ft. Type A*	Type B*
9. Roof deck & roofing, flat roofs			
a. 18-gage metal deck, 1-in. insul. & 20-yr. roof	$1.09/sq. ft.	$1.09	$1.09
b. Same, but with 1½-in. insul.	1.13/sq. ft	1.13	1.13
c. 2-in. poured gypsum on sheet rock & 20-yr. roofing	0.70/sq. ft.	0.70	0.70
d. Same as 9c, but with 1-in. insul. board	0.85/sq ft.	0.85	0.85
e. 2½-in. light weight concrete on H.D. Corruform (or equal) & 20-yr. roofing	0.75/sq. ft.	0.75	0.75
f. Same as 9a, but on slope	1.09/sq. ft.	1.14	1.14
g. Same as 9b, but on slope	1.13/sq. ft.	1.19	1.19
h. Galvanized iron with 1-in. insul. board	0.64/sq. ft.	0.67	0.67
i. Corrugated transite w/1" insul. board	1.12/sq. ft.	1.18	1.18
j. Same as 9i, but without insulation	0.92/sq. ft.	0.96	0.96
10. Alternate structural & roofing system using 40′ span truss deck. (Takes place of units in items 8 and 9 for flat roofs.)			
a. Structural steel	375/ton	0.53	0.59
b. Truss deck, 40′ span, 20-yr. roofing, 1-in. insulation	1.09/sq. ft.	1.09	1.09
11. Heating; 35 F. rise in warehouse			
a. Galvanized iron or transite without insulation board		0.47	0.47
b. Same, but with 1-in. insulation board		0.17	0.17
c. 8" or 12" concrete block & insulated roof system		0.20	0.20
d. Tilt-up & insulated roof		0.20	0.20
12. Miscellaneous items			
a. Coping		0.10	0.08
b. Overhead doors, 10′ x 10′	7.00 ea.	0.14	
	14.00 ea.		0.14
c. Minimum lighting		0.40	0.40
d. Plumbing & drinking fountains (minimum)		0.13	0.13
e. Gutter & downspout		0.04	0.04
f. Painting, other than exterior		0.27	0.27
g. Canopy over overhead doors		0.07	0.07
h. 2,000 sq. ft. of office space—good lights, air-conditioning, additional plumbing, floor covering, acoustical ceiling, etc.	10.00/sq. ft.	1.33†	0.67†
i. Shelving, fork lift trucks, cages, etc. $30,000 allowed		2.00	
$45,000 allowed			1.50
j. Outside construction: Loading dock slab		0.50	0.50
Landscaping & walks		0.30	0.20
Railroad siding	13.00/lin. ft.	0.33	0.20
k. Engineering, supervision, inspection by company staff	2½%	0.17	0.17
l. Contingency & misc	5%	0.34	0.34

*Type A—15,000 sq. ft., 100 ft. × 150 ft.; *Type B—30,000 sq. ft., 100 ft. × 300 ft. †Additional

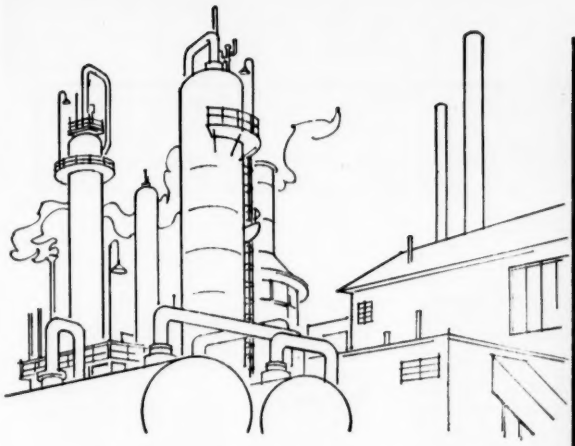
Examples**

No. 1: 15,000 sq. ft. brick veneer heated warehouse, including 2,000 sq. ft. good office space; railroad siding on one side, truck dock on other; truss deck roof system; column spacing 50′ x 40′.

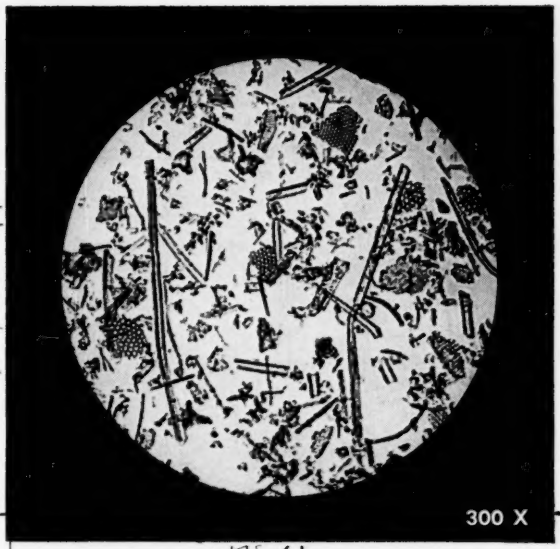
No. 2: 30,000 sq. ft. unheated warehouse without offices; galvanized iron, rigid framed; 100 ft. clear span.

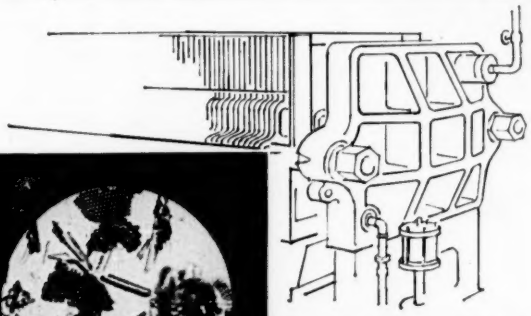
	Cost, $/Sq. Ft. No. 1	No. 2
1. Site work	$0.10	$0.07
2. Permits, temporary const	0.20	0.13
3. Foundations		
a. Footing	0.082	0.065
b. Interior pads	0.01	
c. Interior piers	0.01	
d. Concrete stem, floor at grade		0.074
f. Concrete 8" X 6′ 0" stem wall, etc, for floor at dock height	0.63	
h. Brick veneer	0.12	
4. Fill		
a. Floor at dock	0.22	
b. 6-in. granular base	0.15	0.15
5. Floor, 6-in. concrete, etc	0.70	0.70
6. Exterior walls		
a. 15′ walls, rigid frame (6) Galvanized iron		0.37
b. 18′ walls, truss deck (1) 8-in. concrete block	0.82	
(7) Brick veneer	0.79	
7. Gable ends		
f. Galvanized iron		0.06
8. Structural steel		
a. Rigid frame (3) 100-ft. clear span		1.16
9. Roof deck & roofing		
h. Galvanized iron, insulated		0.67
10. Alternate structural system & roof		
a. Structural steel	0.53	
b. Truss deck & roof	1.09	
11. Heating		
c. Concrete block, insul. roof	0.20	
12. Miscellaneous		
a. Coping	0.10	
b. Overhead doors	0.14	0.14
c. Lighting	0.40	0.40
d. Plumbing	0.13	0.13
e. Gutters & downspout	0.04	
f. Painting	0.27	
h. Offices, 2,000 sq. ft. of bldg	1.33	
j. Outside slab, truck	0.50	
Railroad siding	0.33	
k Engineering, etc	0.17	0.17
l. Contingency	0.34	0.34
Cost of building, $/sq. ft.	**9.402**	**4.629**
Total cost of building	**$141,000**	**$138,900**

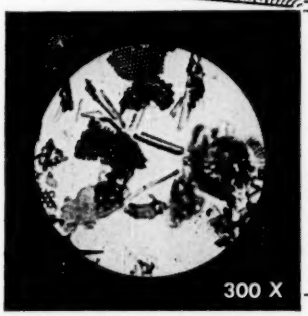
** Numbers in the example tabulation correspond to numbers in the complete tabulation in Cost File 25 and above, q.v. for complete item definition. Where no cost is given for example, item doesn't apply.



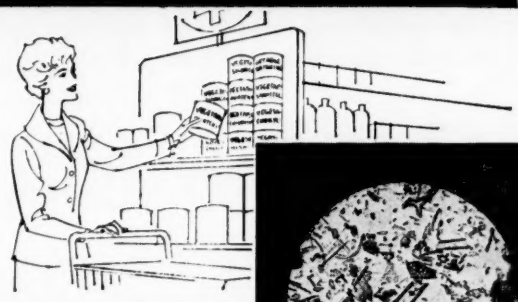
For flow rate plus clarity—Hyflo Super-Cel has the right combination of large and fine particles. Heavily used in chemical processes such as caustic soda production.



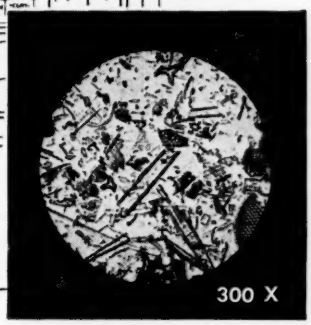




For fast flow rates—Celite 545 has a higher proportion of coarse particles. Frequently used for clarification of resins and other viscous liquids.



For maximum clarity—Filter-Cel has a relatively fine particle size distribution. Used in producing lard, salad oil, other hydrogenated oil products.



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Celite has the exact grade for every filtration need from fast flow rate to maximum clarity

Study samples of various filtration grades of Celite* diatomite with the unaided eye. Rub them between your fingers. One grade looks, feels very much like another.

Then compare these grades under the microscope. Each has its own distinctive particle size distribution. Each is precision-milled to fill the most exacting filtration requirements, ranging all the way from maximum flow rate to maximum clarity.

Celite 545, for example, with a higher proportion of large to fine particles, is used to remove large suspended impurities at maximum flow rates. *Hyflo Super-Cel®* has a balanced particle size distribution, combines good liquid clarity and moderate flow rate. But *Filter-Cel®* has a much higher ratio of small particles, is tailored for use where high clarity outweighs flow rate.

Whatever your filtration problem—Johns-Manville can furnish the "right" grade for the job. You have a choice of 9 intermediate grades *plus* many special grades. Each comes from the largest and purest commercially available deposit. Each is processed and graded at the same plant under the same uniform conditions.

For information on specific filtration or mineral filler problems, talk to your nearby Celite engineer, or write to us. Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada, Port Credit, Ont.

*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

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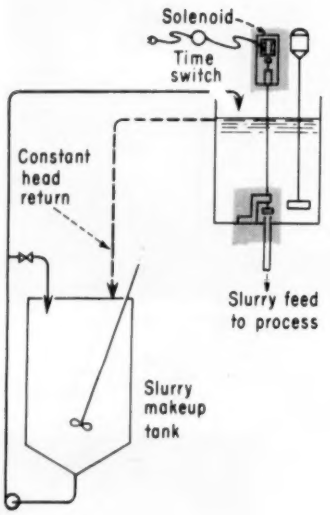
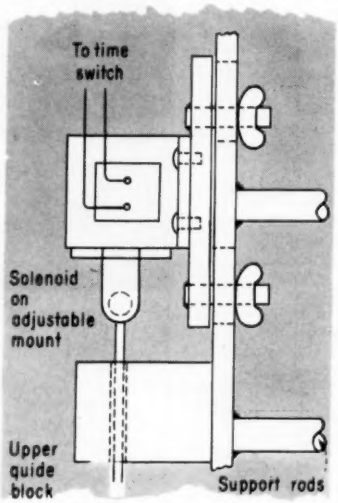
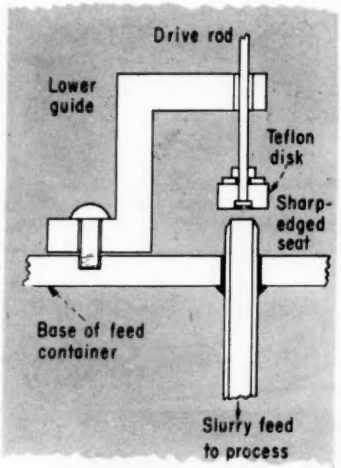






Slurry Feeder for Pilot Plants

Easily built device with positive shutoff knife-edge valve permits accurate control of solid-liquid suspension flow.

Gordon MacBeth
Production Technical Service Dept., Dow Chemical Co., Pittsburg, Cal.

In a recent miniplant study, we were faced with the problem of metering a small slurry flow into a continuous reaction system. We overcame the problem with the feeder shown in the sketch.

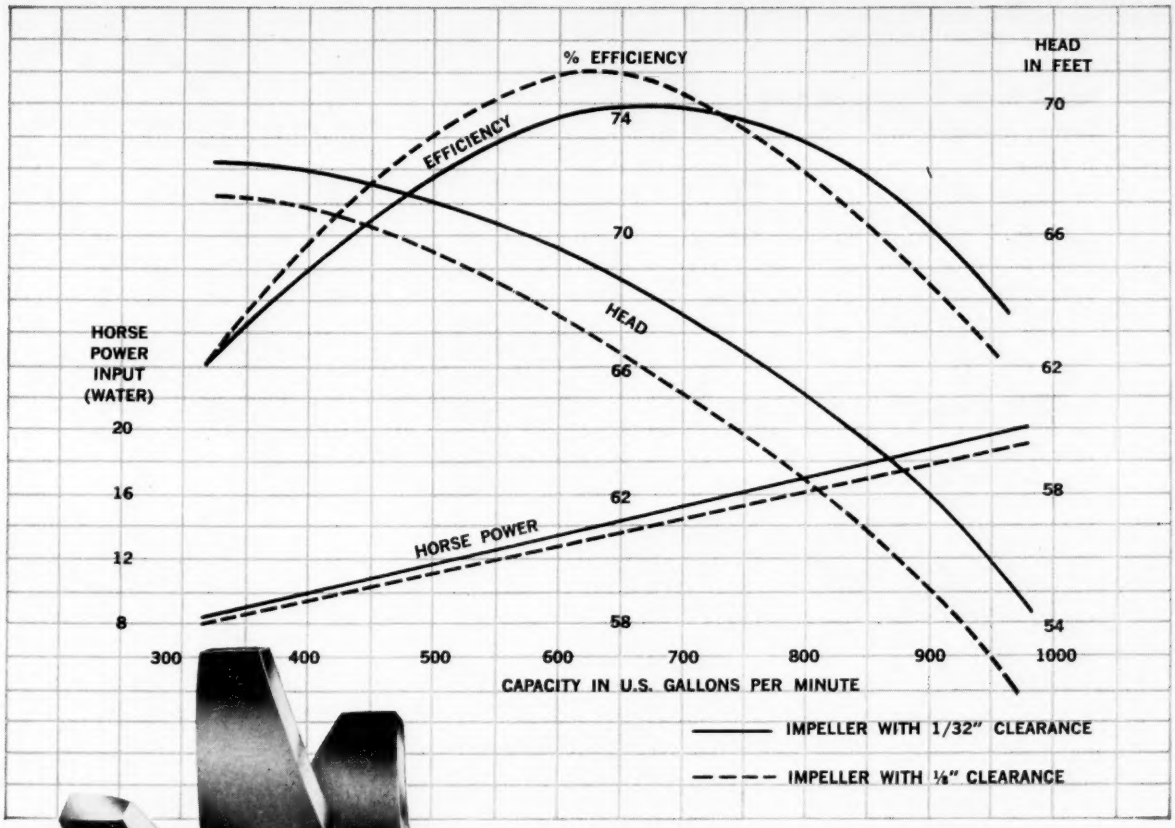
Essential features of the feeder are a sharp edged seat and a flat disk. A solenoid and time switch raises the disk from the seat at intervals to permit a flow of slurry. Because of the brief on-time, the valve opening can be large permitting passage of coarse particles.

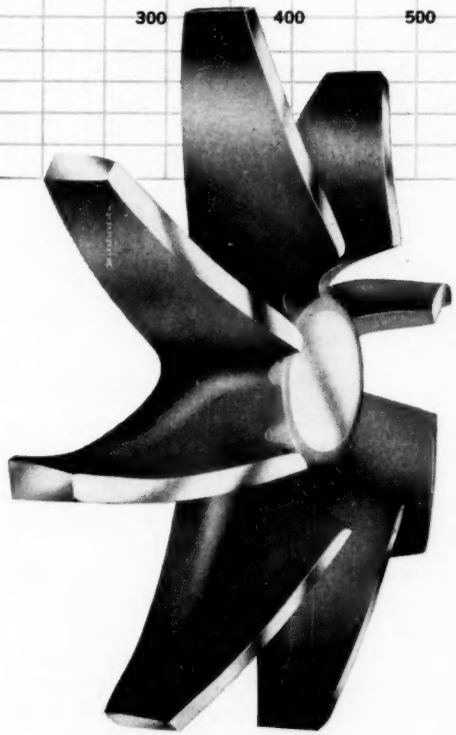
High seating force provided by the sharp edge seat and spring loading of the disk permits tight shutoff despite the presence of solids in the slurry.

You can adjust the flow rate by varying the percent on-time of the solenoid, the stroke, the liquid head or any combination of all three. In our installation, we fed a slurry containing 15% solids at 2 lb. of solids/hr. with a $\frac{1}{4}$-in. stroke and less than 10% of the 10-sec. timer cycle as on time. A given unit has a wide range of capacity but can be regulated closely at any capacity desired.

In our unit, shown in the sketch, an 85-ohm a.c. solenoid and a 10-sec. cycle time switch operated the feeder. A small centrifugal pump with air motor drive and mechanical seal circulated and transferred the slurry.

To provide visual observation of the feed rate and to simplify material balances, we made our feeder from a calibrated glass battery jar. However, this required a special bottom fitting. A metal container would simplify construction. With the alternate constant head provision, the feed rate could be checked by gaging the makeup tank at intervals.





The Impeller that *KEEPS ITS YOUTH*

Your concern for the efficiency of a centrifugal pump shouldn't cease just because you've seen it operating acceptably upon installation. As time goes by and internal clearances are increased by wear and corrosion, will you continue to get the performance you expect?

If you've specified a LaBour Type Q or Type SQ, the answer is, "Yes." That's because these pumps use no sealing rings or other critical close-running parts on which efficiency depends.

Compare the two performance curves of a typical LaBour pump with standard initial clearances and the same pump after clearances had been deliberately made four times as great. This is real preservation of youthful vigor—and it's done with an open impeller.

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Some Rules of Thumb for Quick Estimations

J. Klengen
The Hague, Holland

Often the weight of a pipe, a vessel head or a steel bar is of some importance in design or cost estimation work. Of course, if great accuracy is required, you will take the time to provide that accuracy. But here are a few rules suitable for approximate "talking" estimates.

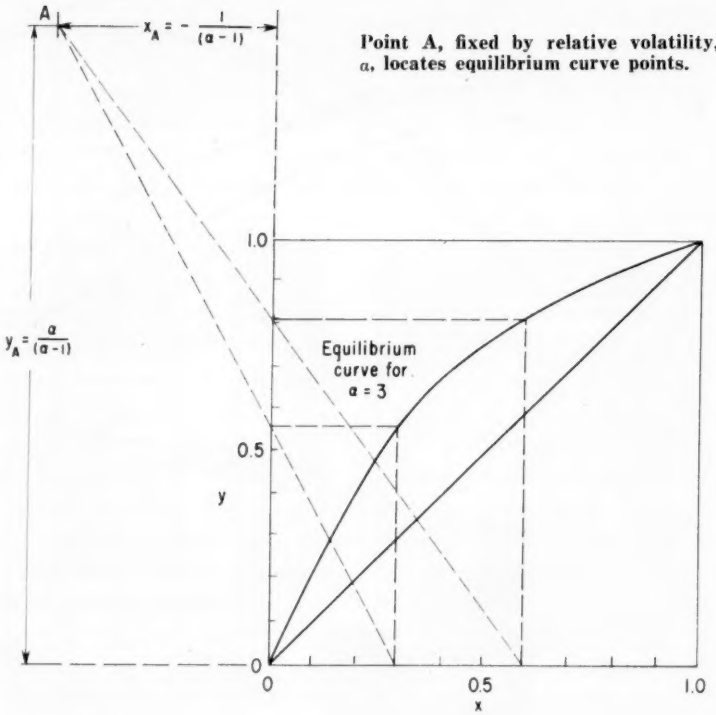
1. The weight of a yard of carbon steel pipe is equal to the outside diameter in inches times the wall thickness in in./32. Thus a 10 in. pipe with $\frac{9}{32}$ in. wall weighs $10 \times 9 = 90$ lb./yd.

2. A yard of round steel bar weighs as much as 8 times the square of the diameter in inches. A 10 in. bar weighs $10^2 \times 8 = 800$ lb./yd.

3. A square steel bar comes to 10 times the product of its sides per yard. A bar 8 in. by 10 in. weighs $8 \times 10 \times 10 = 800$ lb./yd.

4. The weight of a steel dished head (where $R = 0.8D$) is approximately the diameter in feet squared times the wall thickness in in./8 times 7. A 10 ft. head $\frac{3}{8}$ in. thick weighs $10^2 \times 5 \times 7 = 3{,}500$ lbs.

5. Weight of a foot of vertical steel vessel equals the O.D. in inches times wall thickness in in./16. This includes allowance for manholes, reinforcement rings, etc.



Point A, fixed by relative volatility, α, locates equilibrium curve points.

Short-cut to Equilibrium Plots

Ferdinand Rodriguez
Asst. Professor, School of Chem. & Met. Eng., Cornell U., Ithaca, N. Y.

Vapor-liquid equilibrium of a binary liquid mixture is often represented by the equation

$$y/(1-y) = \alpha\, x/(1-x)$$

where x and y are the mole fractions of the more volatile component in the liquid and vapor respectively and α is the relative volatility. Usually, one must prepare an x, y diagram for such a system to perform graphical distillation calculations.

Here is a short cut for preparing such diagrams. First, locate point A at $y = \alpha/(\alpha - 1)$ and $x = -1/(\alpha - 1)$. Then lay a straightedge on point A and any value of x. The line will intersect the corresponding value of y in equilibrium with x on the y axis.

The sketch above gives a general idea of how it is done. After plotting several points as shown, draw a smooth curve between them. This is the equilibrium curve.

You can use the same equation and plotting method to convert mole fraction to weight fraction of component A if α is the ratio of the molecular weight of A to component B in the mixture.

NEXT ISSUE: Watch for February Contest Winner

★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebook.

Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.

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Write for Bulletin 13-17. It explains fully why the Type 12A Temperature Transmitter gives better performance with lower installation and maintenance. **The Foxboro Company 363 Neponset Ave., Foxboro, Mass., U.S.A.**

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Pneumatic Temperature Transmission

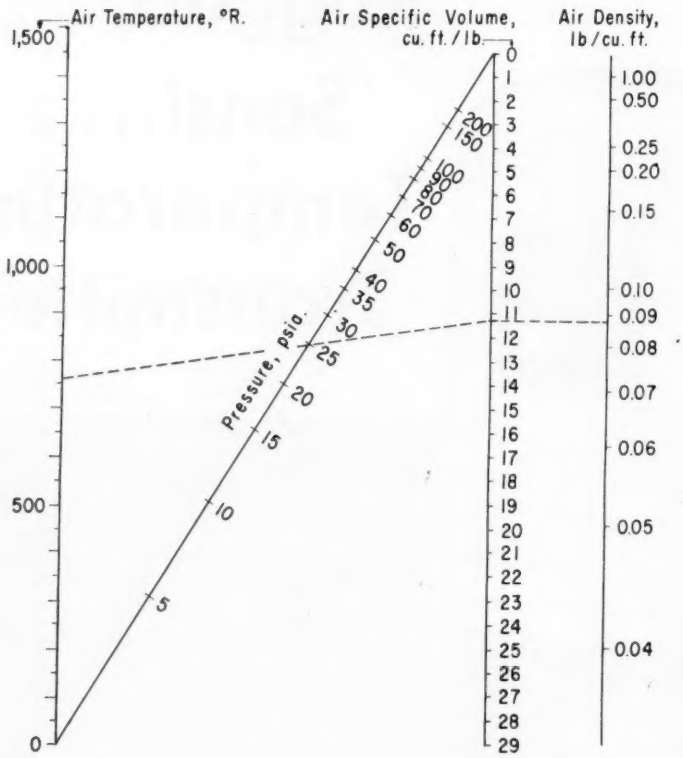


Chart Finds Volume or Density

Jerome A. Seiner
Development Engineer, Pittsburgh Plate Glass Co., Springdale, Pa.

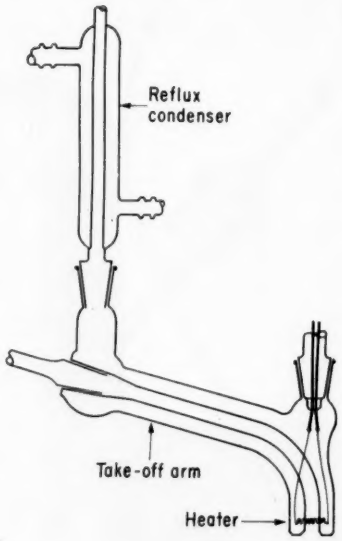
Determination of the specific volume or density of air, when the pressure and temperature are known, is normally quite simple. However, as with most simple calculations, the solving of a large number of such problems can become an extremely tedious chore.

Engineers who must deal with heating and ventilation problems, compressed air production and transmission and processes requiring large quantities of air may find the chart above quite useful in relieving the tedium of many small, simple, time-consuming calculations.

Our nomograph shows temperature in degrees R. at the left and two scales for specific volume, in cu.ft./lb., and density, in lb./cu.ft., at the right. Pressure, in lb./sq.in. absolute, is depicted on a diagonal line between the temperature and specific volume scales.

Use of the nomograph is quite simple. Knowing the temperature and the absolute pressure, lay a straightedge on these points on the appropriate scales. Read the specific volume and/or density from the scales at right.

For example, if the temperature of the air is 300 F. and the pressure is 10 psig., convert to degrees R. and psia. Corrected temperature is then 760 R., and the pressure becomes 24.7 psia. Lay a straightedge between these points and read off specific volume = 11.4 cu.ft./lb. and density = 0.088 lb./cu.ft.



Heated Arm Simplifies Solids Distillation Problem

Adalbert Farkas and M. H. Ziv
Houdry Process Corp., Marcus Hook, Pa.

Distillation of a high melting solid can be difficult. The vapors tend to solidify in the take-off arm from the flask because it is hard to maintain the arm at an even temperature high enough to prevent this.

We solved the problem with the take-off arm shown in the sketch. We have used this arm successfully in the distillation of such compounds as 2-methylimidiazole (m.p. 140 C., b.p. 267 C.) and triethylenediamine (m.p. 157 C., b.p. 178 C.)

An electrically heated coil (2 or 3 ft. of No. 34 or 36 Nichrome wire) supplies heat to a boiling liquid inside the jacket on the take-off arm. A reflux condenser installed on the arm in the manner shown prevents evaporation of the boiling liquid from the jacket.

You can adjust the temperature of the arm to any desired level with the proper choice of heating medium. This may be one compound or a mixture (we used xylene and cumene in the examples above.) The temperature can be changed during operation by addition of either high or low boiling component to the mixture in the arm.

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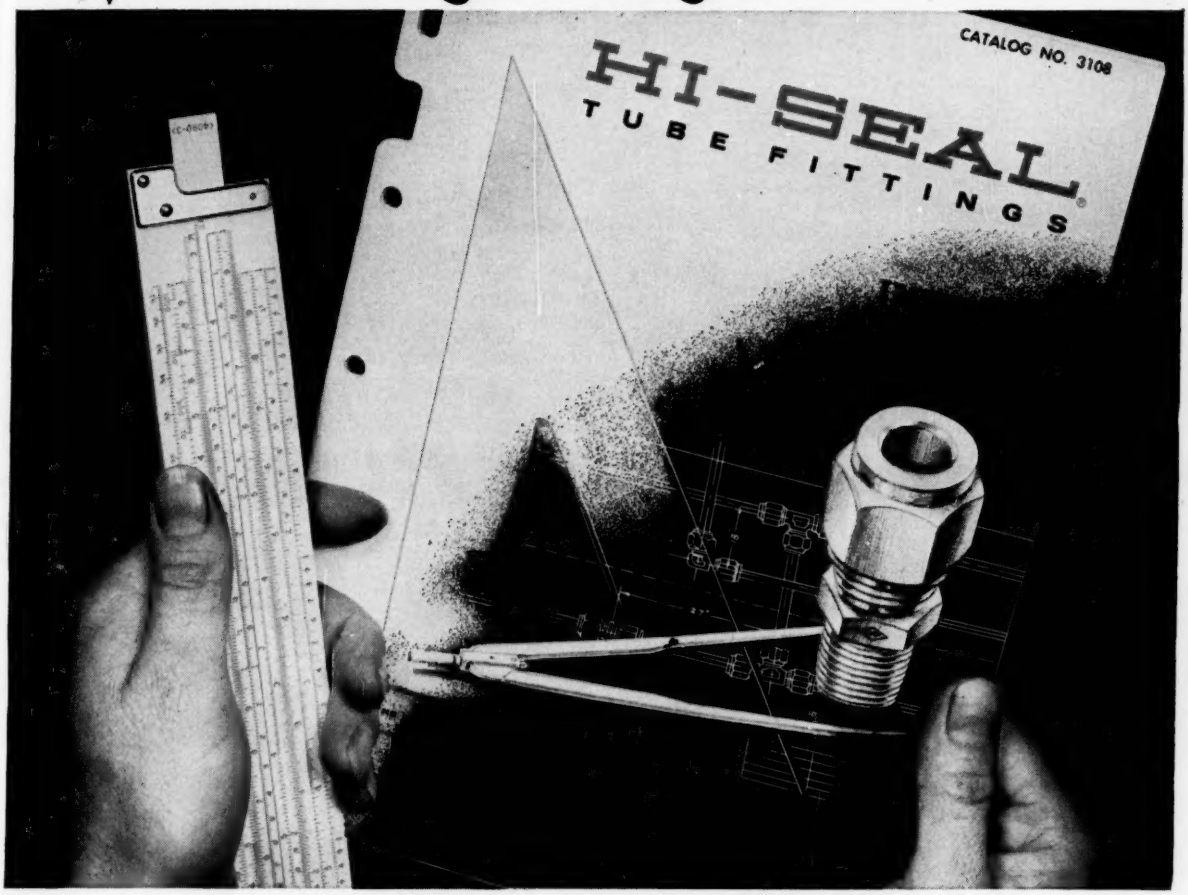

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Just off the press! A working handbook for every man concerned with tubing and fitting circuitry. Published by the company with a habit of leadership.

Leading hydraulic and pneumatic engineers, when asked to study advance proof copies of Imperial's new Hi-Seal Catalog, came back with comments like these: "It's a reference manual" . . . "The kind of material I've had to dig up for myself, until now, from several reference sources" . . . "Make sure I'm on your list for a copy as soon as they are available."

The new Imperial Catalog of Hi-Seal tube fittings contains data, charts, laboratory tests, and formulae on corrosion, vibration, temperature, pressure and vacuum, flow and velocity — vital statistics in hydraulic and pneumatic tubing circuitry design. And it describes the complete line of Imperial Hi-Seal Tube Fittings — *industry's most complete line,* based on a single-design concept, that meets all tubing circuitry requirements. All items in this catalog are stock items and are priced as stock items.

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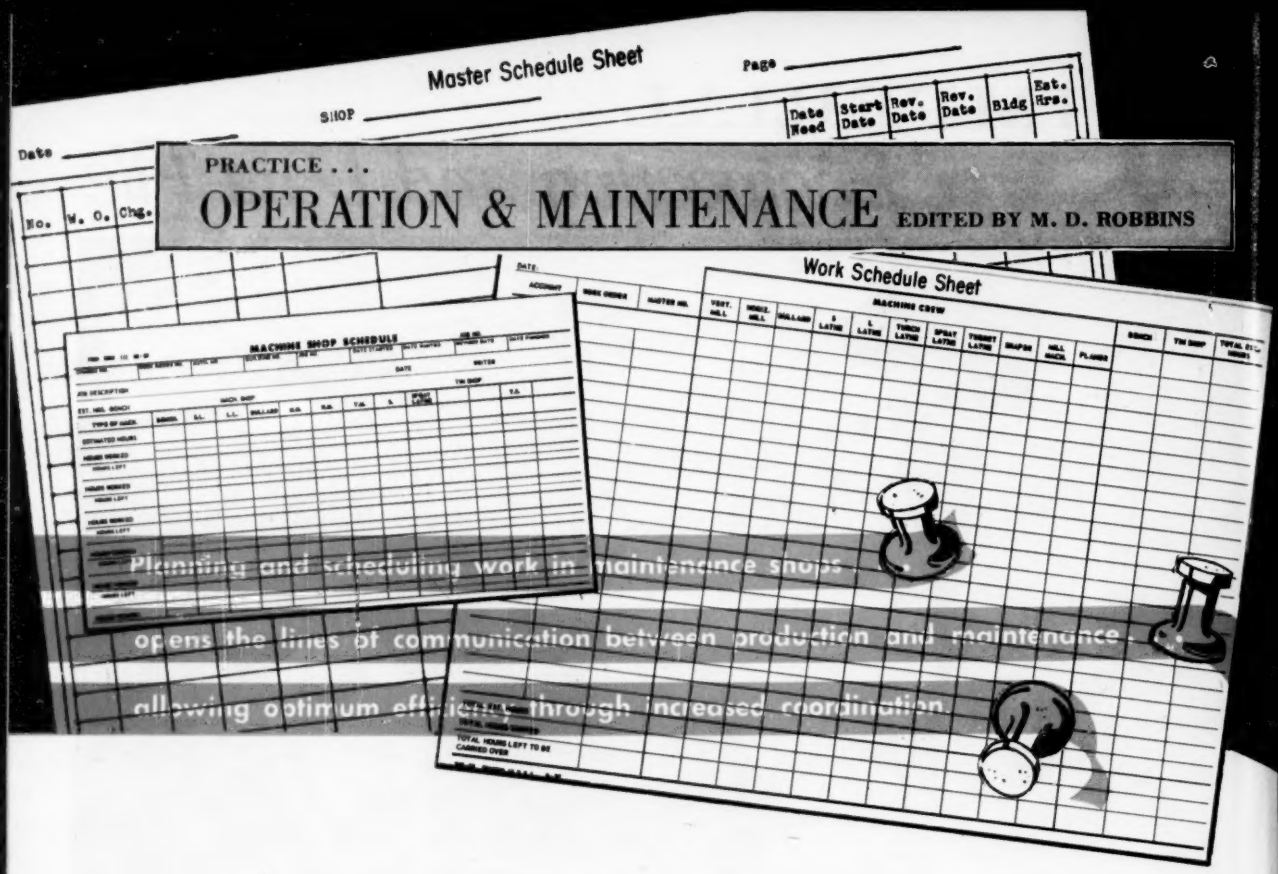

Master Schedule Sheet
PRACTICE . . .
OPERATION & MAINTENANCE
EDITED BY M. D. ROBBINS
Work Schedule Sheet
MACHINE SHOP SCHEDULE
Planning and scheduling work in maintenance shops
opens the lines of communication between production and maintenance
allowing optimum efficiency through increased coordination

Scheduling Keeps Costs in Line

H. L. Timmons, Maintenance Dept., Dow Chemical Co., Midland, Mich.

Maintenance scheduling is a comparatively new field. In fact, until quite recently not many people felt such a program would work effectively due to constantly changing demands on maintenance caused by sudden breakdowns, shifting sales requirements and the like.

As a function it's slowly proving its way, however, principally by demonstrating that it's an effective tool for keeping maintenance costs in line. In today's chemical world this obviously makes it a subject of growing interest.

How Maintenance at Dow's Midland Div. is Organized

Dow's maintenance department is headed by a manager and an assistant manager of maintenance. Reporting to them are two section superintendents, a field superintendent and a supervisor of planning and scheduling.

At the next level there are 11 central shops, which includes practically all trades; most of these shops have field crews working throughout a 1,500-acre plant that encompasses almost 600 buildings.

Seven area shops are also included in the organization to take care of all small maintenance problems in a given plant area. Altogether, the maintenance operation includes about 1,600 men in the shops and the field.

A maintenance scheduling program was installed six years ago. It functions as part of the company's maintenance organization and must be considered as an integral part of this organization. Although we do operate a field scheduling program, this discussion will refer only to shop work to avoid confusion.

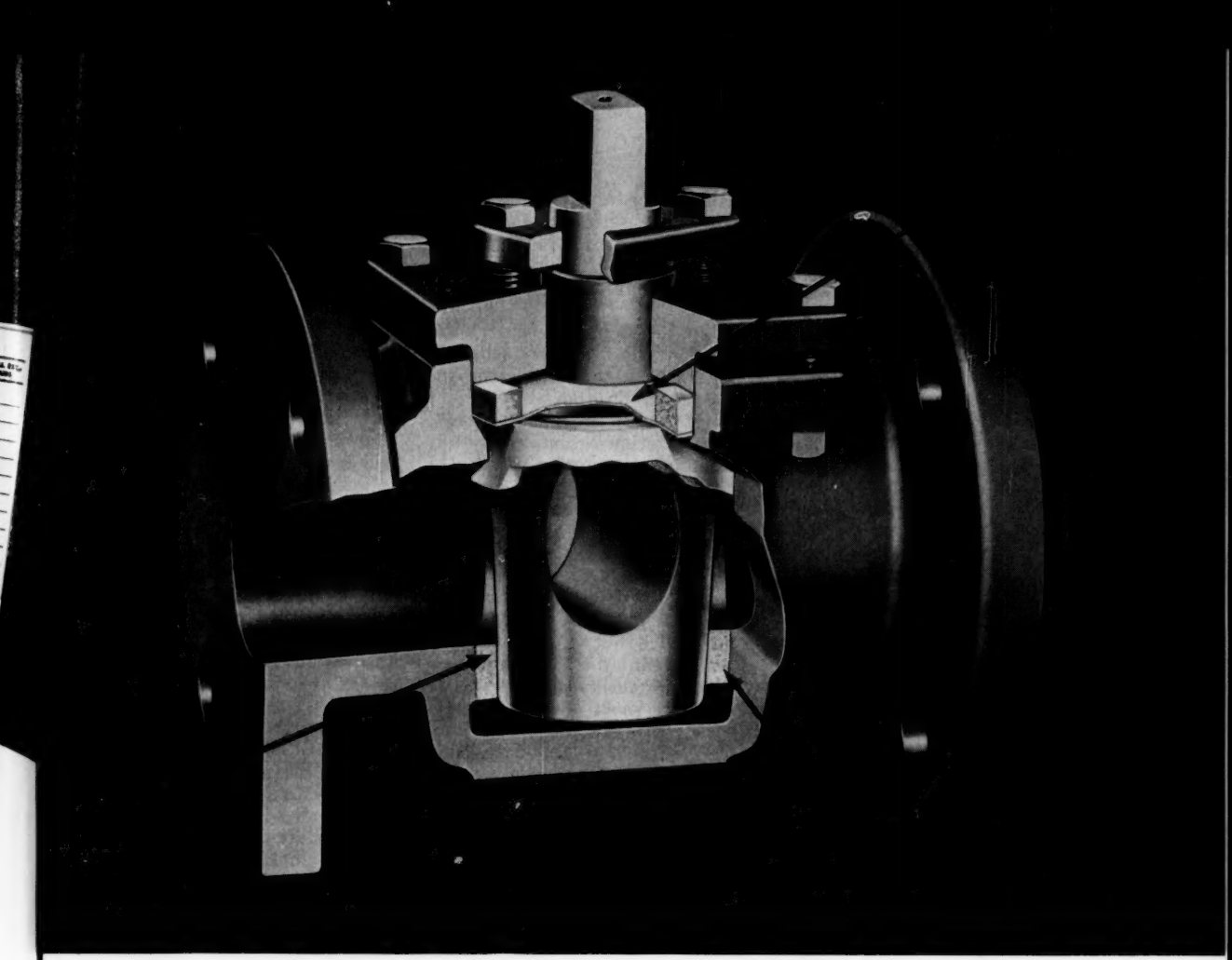
Currently, five of the central shops are under scheduling: boiler, machine, tin, pipe and the auxiliary machine and tool and die shop.

Slow Start Helps

Our maintenance scheduling program at Midland was installed with as little disruption to the operation of each department as possible. While there are several reasons for doing it this way, the chief ones are:

- Lowered resistance to such a change.
- Office work and paperwork changes kept to a minimum.

This program was installed one shop at a time, being sure it was working well in one shop before launching it in another. This is much easier and less alarming to everyone concerned. In other words, it was installed gradually rather than as a rush



THROW OUT LUBRICATED PLUG-VALVE PROBLEMS

Install non-lubricated DURCO Type G Sleeveline valves

Wherever you have cast iron or semi-steel valves that stick, gall, break, leak thru, or otherwise cause maintenance nightmares, install ductile iron Durco Type G valves with Teflon sleeves.

Durco Sleeveline valves are available in ductile iron or stainless steel, screwed or flanged ends, from ½" through 6", with 150 psi rating.

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program and this is a definite asset to its effectiveness.

You must closely scrutinize the advantages and disadvantages of a maintenance shops scheduling program. You have to answer many questions: How many men will such a program require? How much should be scheduled? How much will it cost? How much will it save the company? These are just a few; there are many others.

It is rather difficult to answer some of these questions, but after taking a good look at similar installations in other plants, our program was initiated.

Approximately 75% of the available productive time in each shop is currently scheduled. This excludes supervision, crane operators, clerks, etc. Scheduling personnel consist of a supervisor and three schedulers. All are trained to schedule in any shop, which gives flexibility in cases of sickness and vacations. Estimating is done by a separate department not connected with the maintenance department.

A SMALL JOB

Let's follow a simple job through a shop on a step-by-step procedure, taking as an example the fabrication of a 5-ft. by 5-ft. steel storage tank:

Step 1 —The **job is estimated** to take 10 hr. for layout, 25 hr. for fabrication and 15 for welding. All material is on hand at the stockroom.

Step 2 —**Job is recorded** on the work schedule sheet. This sheet is prepared daily and shows all work received for each day, with layout fabrication and welding breakdown per estimate and a total for each job.

Step 3 —The order originator is asking for this job in ten days. Scheduler **checks his present schedules** and determines this is impossible.

Step 4 —Scheduler contacts the production man concerned to **determine what priority** this job carries. He finds the job can be scheduled five days later without a serious loss to production. This schedule can be met without interference to other schedules.

Step 5 —Scheduler **enters the job on the master schedule sheet.** This carries all the information on the work order: work order number, charge, authorization number, writer, brief job description, scheduled completion date, actual starting date, revised schedule date if there is one, building number, where job will be used and total estimated hours.

Step 6 —A **schedule card is now filled out** in duplicate by the scheduler which shows all the information on the master schedule sheet plus the estimator's job breakdown. This card also will show the dates and hours worked on each step of the job. This is filed at the scheduler's desk.

Step 7 — Scheduled **completion date is now stamped** on the face of the work order.

Step 8 — A **schedule board card is filled out** which shows the charge, work order number, estimated hours, brief description of work and scheduled completion date. This card is put on the board located in the department office as a guide for the foremen concerned.

Step 9 —The **work order is given to the superintendent** for distribution to the foremen.

Step 10 —The department **office clerk records the time spent daily** on all jobs. This information goes to the scheduler and he records the time spent on all scheduled jobs on the schedule cards. This gives him the complete progress picture.

Step 11 — Before the estimated time is used up, the scheduler checks the job's progress with the foremen to **determine if the completion date can be kept.** If it cannot, the scheduler notifies the production department concerned and a revised date is set. If the production man decides it is impossible to extend the time and he cannot get a higher priority to put his job ahead of others, he may choose to ask for overtime for his job. Scheduler keeps a close check on the job to be sure it is started in time to allow the completion date to be met.

Step 12 —As mentioned, the **schedule card** is made out in **duplicate.** The second copy is taken to the scheduling and planning office where it is **inserted in a Produc-Trol Schedule Board.** At this office each shop has a board on which all scheduled jobs are recorded and progress is noted. There are also two boards for what are called master orders. These orders cover jobs involving the work of more than one shop.

A BIGGER JOB

The above scheduled job was a very simple one. Now let's take a more complex example and follow it through.

This is a "master-order job." It involves the boiler, pipe and machine shops. Let's assume the work consists of fabricating three tanks that have cooling coils and two special pumps. Pumps are to be mounted on bases complete with drives.

The supervisor and the three schedulers meet and survey the complete job and determine what each department's work will be. Bill of material is checked to determine what parts are to be purchased outside the plant and what parts are in stock.

Pump motor has to be purchased and delivery is promised in three weeks. Tank heads have to be purchased and delivery is promised in ten days. All other material is on hand. Asking completion date is six weeks. Estimated man hours of work for each department are as follows:

Boiler shop:	200 hr.
Pipe shop:	75 hr.
Machine shop:	150 hr.

Pipe shop scheduler will be able to have the tank cooling coils ready well ahead of the boiler shop's needs since the boiler shop cannot start the job before receipt of the tank heads, in ten days. Scheduling super-

visor therefore decides that the coils should not be started until some other jobs are completed. This will still leave plenty of time to meet boiler shop schedules for the tanks without holding up the job's progress.

Fabrication of the pumps can proceed immediately, since the motor will be the last installation of the pump fabrication. For the most part, the pumps require the work of only one man so it is necessary to start as soon as possible to meet the required completion schedule.

Boiler shop cannot start until receipt of the heads in 10 days. A check is made prior to the head and motor delivery promises, to determine if they will be kept. If they cannot, all schedulers are notified; they in turn revise all shop schedules concerning the job. (In some cases it may be well to continue the job as far as possible.)

All paper work is done in the same way as in the first example.

Priorities Are Important

The above examples have covered the scheduling in some detail. From them it's evident that one of the most important things the scheduler has to determine is priority or importance of each job.

With the proper priority he can schedule efficiently and effectively. Without the proper priorities a scheduling program becomes a waste of time and money.

The question then is, "How do you establish proper priorities for each job"?

This isn't always easy and at Dow we don't feel we are always correct, but the number of complaints from production people have decreased considerably since the scheduling program was installed, and this is a good indication that we usually have the proper priorities. Presumably a scheduler's judgment improves with practice.

Maintenance scheduling is assisted by the production control department, which furnishes up-to-date information on those products most important sales-wise, the products on which downtime would result in heavy losses to the company. This information is invaluable to the scheduling department in determining priorities.

Usually a priority can be established by contacting the production people involved. Once they learn the scheduling program is conducted in their best interests and that realistic schedules usually can be kept, they are most cooperative in helping establish true priorities.

Cooperation With Production

As mentioned, we schedule approximately 75% of the available productive hours in each shop daily. This leaves 25% of the shop's time for small jobs and as a cushion for some emergency work. These percentages have worked quite satisfactorily in most cases.

With more refinement of the program we will be able to schedule possibly as much as 80 to 90% of the time in some shops.

In each shop, jobs of a certain size are scheduled. For instance, in the boiler, machine and auxiliary shops, jobs estimated to require 20 hr. or more are scheduled.

The pipe shop is scheduled on jobs estimated to take 8 hr. or more. Pipe shop work is usually not nearly as large hourwise as the other shops, and this schedule represents approximately 75% of its work.

Production people often ask that even smaller jobs be scheduled, and this the schedulers are glad to do at any time. Naturally the section does have to be certain that it has a cushion of about 25% to take care of small emergency work.

Shop scheduler never sets a starting date. This is left to the supervision to determine. Important thing is that the completion date is met. Occasionally, of course, a supervisor will ask the scheduler when he thinks work should start on a certain job, and this shows a good relationship between the department and scheduling.

A highly important function of the scheduler is to keep production notified of any and all schedule changes. This allows the production people to plan their work smoothly around shut-downs, changeover, etc.

Benefits Speak for Themselves

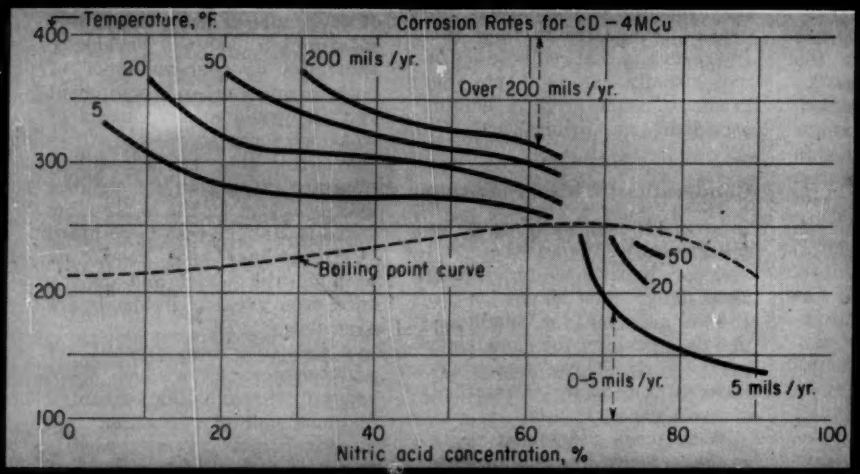
Through scheduling, management is able to keep better informed of a number of problems that otherwise might go undetected for a considerable time. It gives management immediate information as to workloads, shortages or overabundance of both manpower and equipment and also yield measurements of work efficiency.

We feel that the scheduling program is still in its infancy and recognize that it is far from perfect. But the results obtained thus far have been good, and with greater effort and experience even greater dividends are expected.

A considerable amount of maintenance costs has been reduced through this planning and scheduling program. To measure these savings exactly is a very difficult job because of the number of measurements that have to be taken.

A major problem in practically all plants is the maintenance of good lines of communication. In many cases this is an exceedingly difficult problem, especially in large plants. Scheduling has definitely lessened our problem. This is true because practically every department is either directly or indirectly connected to the program. This is one of the "extra dividends" resulting from this program.

HAROLD L. TIMMONS was born and educated in Midland, Mich. He joined Dow 25 years ago as an apprentice machinist following high school; later became machinist foreman at the Bay City Division in 1940, maintenance coordinator at Midland in 1948, maintenance scheduler in 1955 and was made planning supervisor, his present position, in 1957.



Corrosion Rates, ipm.

	CD-4MCu	17-4PH	Stainless W	AM 350	CF-8M
50% H_2SO_4 at RT	0.00167	Dissolves	Dissolves	0.00157	0.1130
5% HCl at RT	0.0058	0.0654	Dissolves	0.0239	0.0414
65% HNO_3 at boiling	0.00119	0.0587	0.0305	0.0150	0.0019
10% $FeCl_3$ + 0.1% HCl at RT	0.0260	–	–	–	0.0277

Stronger Cast Stainless Keeps Promises

First definitive lab and plant performance data show cast CD-4MCu alloy living up to its early claims: double the strength of 18-8 with excellent corrosion resistance.

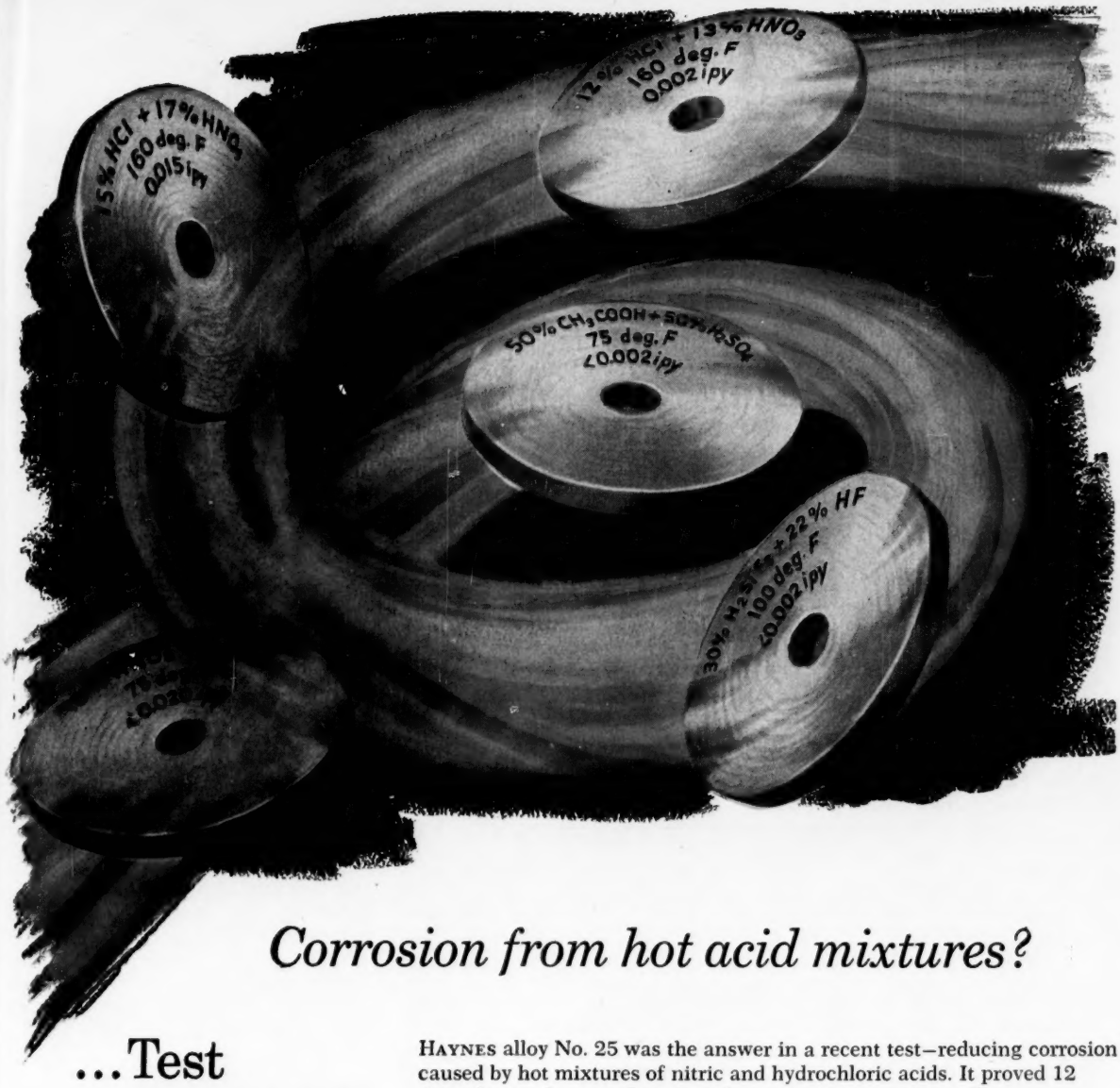
E. A. Schoefer, Alloy Casting Institute, Garden City, L. I., N. Y.

A trend toward increased temperatures and pressures, and highly corrosive conditions in today's chemical processes imposes some very harsh requirements upon equipment and creates strong demands for alloys with improved properties.

In looking at existing materials for combined severe-corrosion and high-stress situations, a designer will quickly come face-to-face with an unsatisfactory situation: the usual 18-8 stainless alloys have excellent corrosion resistance at reasonable cost but can be hardened only by cold working—an expensive technique which limits the hardened alloys to strip, sheet or wire forms. Unfortunately, standard 18-8 cannot be hardened and strengthened by a simple heat treatment.

An alloy linking the desirable features of high strength produced by heat treatment and good corrosion resistance, will fill this obvious gap in stainless development.

▶ **New Alloy** — The gap was filled about three years ago with the introduction of cast precipitation-hardening CD-4MCu (Alloy Casting Institute designation). Work was done at Ohio



Corrosion from hot acid mixtures?

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Important Room-Temperature Properties: CD-4MCu and CF-8—Table I

	Heat Treatment	Tensile Strength, 1,000 Psi.	Yield Point, 1,000 Psi., 2% Offset	Elongation %	BHN	Room Temperature Charpy Impact, Key Hole, Ft.-Lb.
CD-4MCu	W.Q. from 1,950-2,050 F.	100-115	80-90	20-30	250-270	37
	Age 3 hr. at 850-950 F.	135-145	100-120	10-25	290-320	12
CF-8	W.Q. from 1,950-2,050 F.	65-85	28-45	35-60	125-150	70

State in an ACI research program. This metal (26% Cr, 5% Ni) has double the strength of CF-8 grade (19% Cr, 8% Ni) with equal or better corrosion resistance.

But the early promise of exceptional corrosion resistance displayed in Strauss and Huey tests has now been confirmed by service data and more extensive laboratory tests on CD-4MCu. The new information will be discussed in detail here, together with data on fabricating characteristics.

It should be pointed out that there are a number of precipitation-hardening alloys available on the market. But most emphasize high strength and not high chemical resistance. An exception to this is a recently introduced series (*Chem. Eng.*, June 15, 1959, p. 210).

Performance of CD-4MCu in a variety of corrosive media is compared with several other commercial alloys in the table on p. 164.

▶ **Good Against Nitric** — This hardenable grade is far superior, for instance, to the widely used Type CF-8M in 50% sulfuric acid at room temperature. Also, tests run at consecutive 48-hr. periods show no tendency for the corrosion rate to increase with time.

Precipitation-hardening CD-4MCu is highly resistant to strongly oxidizing nitric acid solutions. Iso-corrosion curves for the solution-annealed alloy in various concentrations of nitric acid are shown on p. 164 and illustrate excellent resistance at elevated temperatures.

▶ **Tough and Hard**—Type CD-4MCu (see chemistry, Table II) exhibits good ductility in the hardened condition and has better resistance to galling than CF-8 grade in plug valves. In addition, the alloy is easily machined or fabrication-welded and has good foundry characteristics (fluidity and castability).

Mechanical properties of CD-4MCu are compared with those of CF-8 in Table I.

The novel alloy has a two-phase, austenite-ferrite structure. Sigma phase appears in the fully hardened alloy as scattered particles in the ferrite matrix.

▶ **How It's Done**—The relatively simple heat treatment, required to harden and strengthen the new cast alloy, is a prime advantage. To attain the mechanical properties listed in Table I, a two-step heat treatment is adequate for most castings of normal section thickness.

First, for optimum corrosion resistance, castings are solution annealed by water quenching from 1,950 to 2,050 F. In this condition, the alloy has a hardness level in the range of 250 to 270 BHN. For maximum hardness, the alloy is aged for 3 hr. in a temperature range of 850 to 950 F. to achieve a BHN of 290 to 320.

Although CF-8 has better ductility, the elongation values of CD-4MCu are adequate for most applications. Since fatigue strength increases with tensile strength, CD-4MCu has good resistance to cycling stresses, and the alloy displays good toughness. Results of impact tests on specimens in the solution-annealed and aged conditions are also tabulated in Table I.

Allowance for thermal expansion of components must be made in designing high-temperature apparatus. For CD-4MCu, the coefficient of linear thermal expansion, in the range 70 to 600 F., is approximately 6.5 micro-inches/in./°F. This is about equal to carbon steel (5.5) and approximately 40% lower than cast 18-8 grades such as CF-8 (9.5).

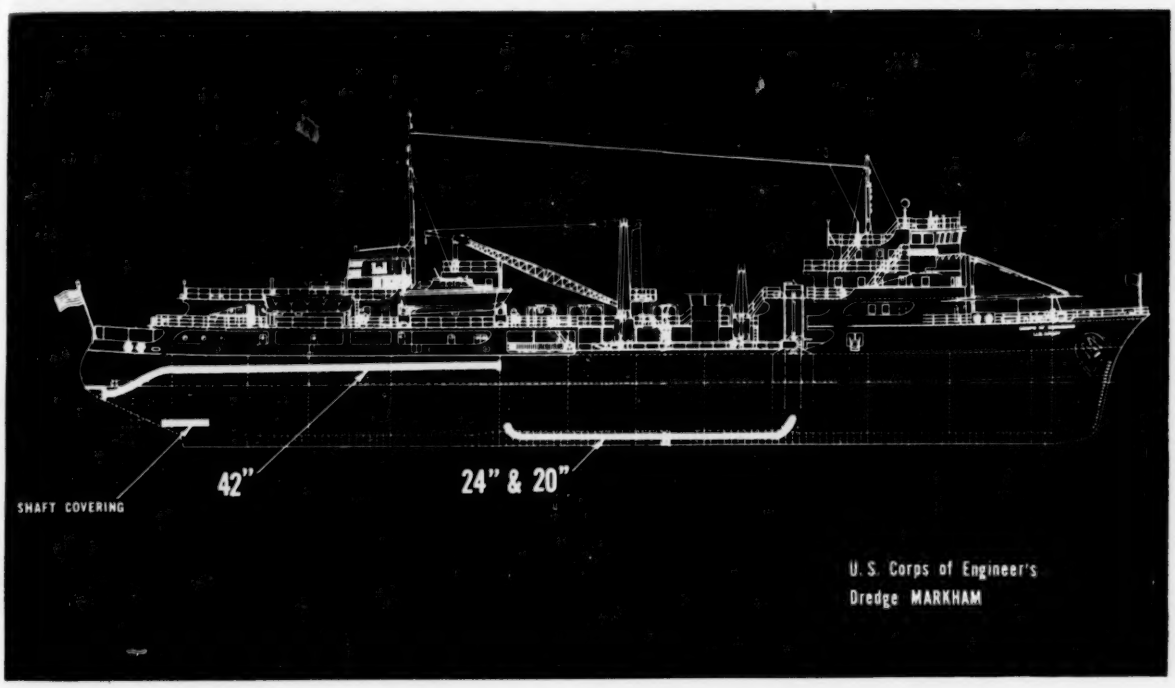
▶ **Welding Techniques** — Tough and ductile weldments are produced in electric arc and Heliarc welding of CD-4MCu, using cast filler rod of the same material. Pre-heating and post-heating operations are not required since the alloy is not susceptible to cracking in the heat-affected zone. For severe corrosive environments, however, re-solution annealing after welding will ensure maximum corrosion resistance and best control of mechanical properties.

Because of CD-4MCu's low-carbon content, there is no problem of intergranular corrosion from excessive carbide precipitation due to welding. A low rate of 10 mils/yr. is typical of welded specimens in boiling 65% nitric acid, with very slight attack in the heat-affected zone of the metal.

CD-4MCu can be readily machined in either the water-quenched or aged conditions. Best results are achieved by machining in the solution-annealed condition, using carboloy tools and speeds slightly slower than for 18-8 stainless. Because of its excellent chip characteristics and freedom from work-hardening, extremely close tolerances can be maintained.

In the foundry, induction melting ensures close chemical-composition control and consistent hardening characteristics. Carbon content must be kept low to maintain corrosion resistance at high hardness levels. The alloy exhibits good castability—feeding characteristics are comparable to CF-8 with fluidity slightly better. Conventional casting de-

PERMOBOND



U. S. PERMOBOND SERVICE BY AVONDALE FOR U. S. ARMY ENGINEERS

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The newly opened St. Lawrence Seaway, most dramatic marine development since the Panama Canal, is to be kept clear by dredges such as the one shown above. Operated by the U. S. Army Engineers, the dredge "Markham" uses Permobond to line its 42" diameter pipes and protect the main propeller shafts.

Permobond® protects the dredging pipes against abrasive action and oil. Permobond also eliminates corrosion from the main shafts when the dredge is working in salt water. The result is longer pipe and shaft life, very little maintenance, and maximum efficiency. The dredge builder (Avondale Marine Ways, Inc., New Orleans) selected and applied Permobond because of its known superiority to any other type of lining.

Because Permobond is unusually resistant to most corrosive chemical and abrasive conditions and can be applied to both new and existing equipment, many chemical manufacturing and processing corporations have already taken advantage of Permobond service protection for equipment

Close-up of the dredging pipes installed by Avondale on the "Markham" after being Permobond lined

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Composition of ACI Types CD-4MCu & CF-8—Table II

	CD-4MCu, %	CF-8, %
C, max.	0.040	0.08
Mn, max.	1.0	1.50
Si, max.	1.0	2.00
P, max.	0.04	0.04
S, max.	0.04	0.04
Cr	25.0–27.0	18–21
Ni	4.75–6.0	8–11
Mo	1.75–2.25	....
Cu	2.75–3.25	....

sign and general foundry practice are all that's necessary.

► **Field Tests Are In** — Newly-launched materials are generally presented to the design engineer as a cure-all for problem applications. Controlled laboratory test data, however, seldom provide dependable criteria for final specification and should be regarded only as a guide to expected performance.

In selecting an alloy for any critical application, the engineer should investigate results obtained in the field under similar service conditions. These reports on actual field applications of cast CD-4MCu alloy offer the designer an effective gage for evaluating its suitability in difficult environments.

A CD-4MCu impeller, installed in a pump at Allied Chemical's General Chemical Div. plant, Marcus Hook, Pa., recently demonstrated the effective performance of this cast alloy.

Circulating a saturated solution of sodium sulfite and sodium carbonate, during one stage in the production of anhydrous sodium bisulfite, the impeller is subjected to punishing operating conditions.

Processed at a temperature of 150 F., attack by this severely corrosive slurry is greatly accelerated; high rates of flow through the impeller cause erosion by high-velocity impingement. The presence of 33% sodium sulfite and sodium carbonate as suspended abrasive solids further intensifies corrosion-erosion action.

► **Others Failed**—Initially, the impeller was cast from ACI Type CF-8 stainless alloy which has a well-earned reputation for good corrosion resistance. Each of four such units, installed successively, lasted from 6 to 9 mo. Failure was due primarily to erosion and abrasive wear, with some degree of corrosive attack.

In an effort to reduce the wear factor, a Type CA-15 (12% chromium) stainless impeller was tried. This impeller, which operated continuously, failed rapidly from corrosion and was removed from service after 5 mo.

General Chemical engineers then installed an impeller cast from the CD-4MCu alloy. This application provided a good test for the high-strength-linked-to-corrosion-resistance claim.

The CD-4MCu impeller operated in continuous runs of 24 hr./day (as did the Type CF-8 units), and was removed from the pump after 17 mo. (equivalent to 8½ mo. of uninterrupted service). The impeller was in excellent condition. Evidence of corrosive attack or wear was negligible.

► **Abrasive Wear** — Cast CD-4MCu components also have been specified for service in continuous processing of Rayflo (an wood-based additive for oil- and gas-well drilling muds). Here, corrosive conditions, coupled with abrasive wear from wood residues, are encountered in the digester cycle. Forming the heart of the rotary feeder in this digester: A liner centrifugally cast from CD-4MCu, and installed at Alaska Pine Co. Ltd., Vancouver, to minimize premature failure experienced with other materials.

In service for 10 mo., the rotary feeder has required no maintenance. Although the unit has not been dismantled, there is no evidence of "blow-back" which would result from corrosion or wear of the liner.

Exposed to acid-liquor fumes, expressed-wood acids, thermal shock from steam at 100 to 105 psi. on the digester side, and relative coldness on the hopper side, the liner is subject to severe corrosive attack. Abrasive wear is also a factor since the liner must resist the constant scouring action of wood residues fed by a rotor into the digester.

Previous liner materials used included Ni-Hard, Ni-Resist, carbon steel hard-faced with stainless steel (outside) and Stellite (inside)—and Type CF-8M cast stainless. Ni-Hard and Ni-Resist failed rapidly—after 3 mo. and 4 mo., respectively. The hard-faced carbon-steel liner required repairs after 4 mo. due to corrosion of the stainless steel coating in the area of the relief ports. Type CF-8M liners provided an approximate service life of 6 mo.

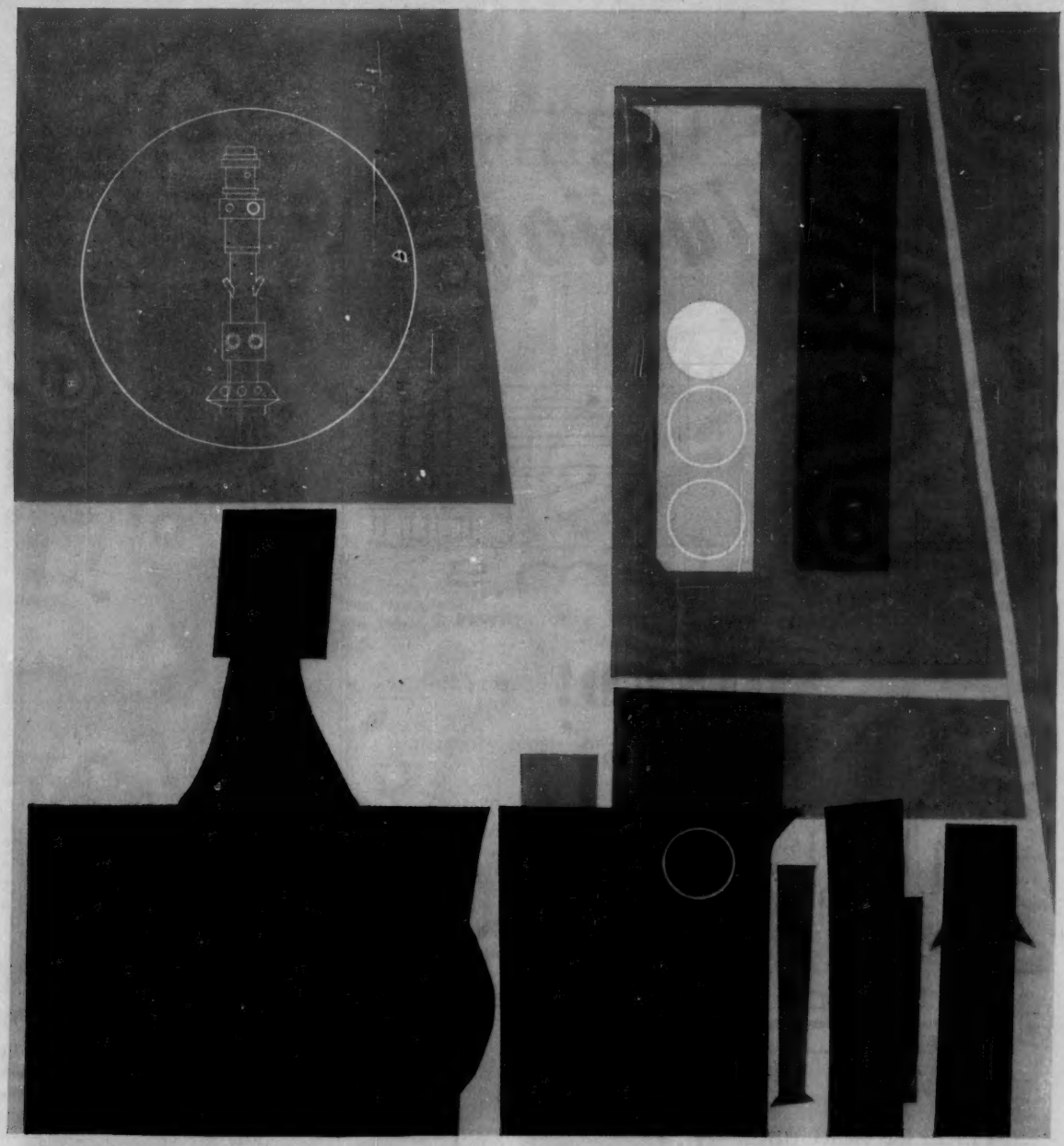
Engineers at this pulp plant and at the American Defibrator Co., manufacturers of the rotary feeder, report that the cast CD-4MCu liner shows corrosion-erosion resistance far superior to any material previously used.

In another application—secondary oil recovery—CD-4MCu reciprocating valves are used in pumps injecting salt water into the ground (operating at 50 gpm. and 1,400 psi.). After handling 80,000 bbl. of brine at a Sun Oil installation, the valves show no corrosion or wear.

The performance of CD-4MCu in these applications recommends its use in many of the basic process industries. Good resistance to pitting, for example, makes it a natural for handling corrosive bleaches and dyes.

► **Nuclear Applications** — CD-4MCu coupons exposed to boiling simulated-reactor-core solutions exhibited very low corrosion rates. Other laboratory test data indicate this cast grade should prove useful in elevated temperature and pressure service in the nuclear field. The alloy's confirmed resistance to corrosive acids suggests broad application in chemical processing. Because of the unusual combination of strength plus corrosion resistance, and the excellent results achieved to date, precipitation-hardening CD-4MCu may well provide the answer to many application problems which cannot be solved with existing alloys.

E. A. SCHOEFER, executive vice president of the Alloy Casting Institute, is a metallurgical engineer and a graduate of Rensselaer Polytechnic Institute. He worked for Republic Steel before joining ACI. Mr. Schoefer is a member of AIME, ASM, ASTM, AFS, AAAS.



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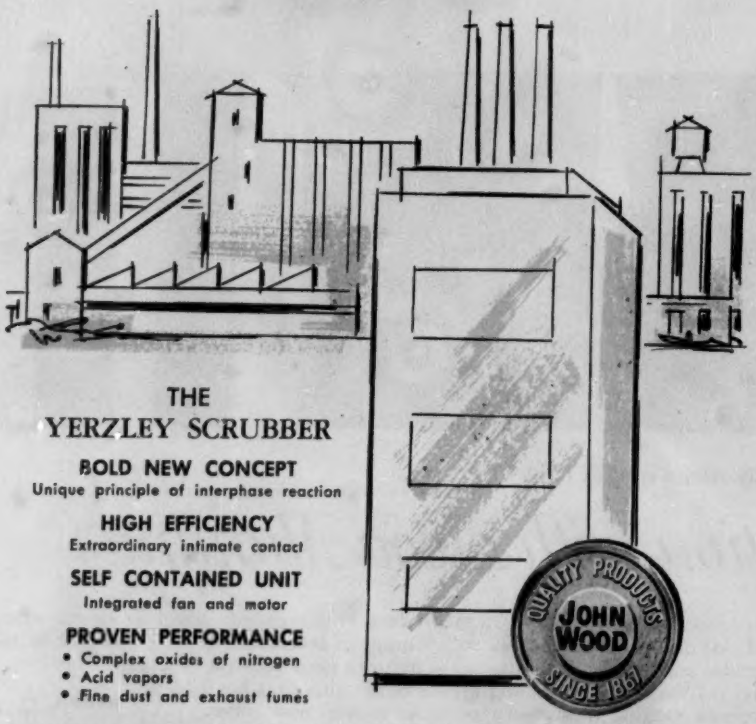

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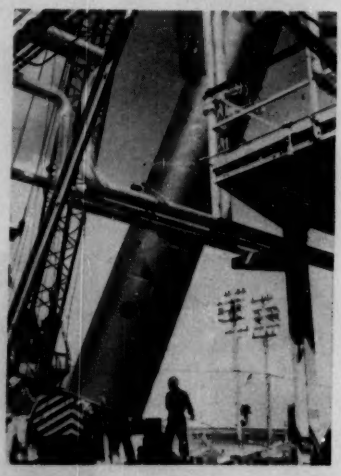
(*Continued from page* 70)

lion expansion, is being engineered and constructed by the Lummus Co. and is the fourth Shell-process ethylene oxide plant to be built by Lummus.



Celanese Plastics Co. is joining the polyethylene expansion bandwagon, is upping high-density polythylene capacity at Houston, Tex., to 25,000 tons/yr. This is the first major expansion of existing plants in the U.S. for high-density polyethylene production.

Borden Chemical Co. discloses plans for construction of a 45,000-ton/yr. resins and formaldehyde plant at Fremont, Calif. Construction schedule calls for completion of the resin plant by April and the formaldehyde plant by the fall.

British American Oil Co. is modernizing its Calgary, Alta., refinery to boost capacity from 7,500 to 10,000 bbl./day. Plans include revamping of existing combination crude topping vacuum and thermal cracking unit and increasing reformer capacity from 2,000 to 3,000 bbl./day.

Union Carbide Nuclear Co. has completed construction of new unit for high-purity tungsten and ammonium paratungstate production at

its Bishop, Calif., tungsten refinery. Unit produces commercial quantities of paratungstate for the manufacture of cemented tungsten carbides, lamp filaments and other materials for the electrical industry.

Tidewater Oil Co. has begun construction of a 100,000-bbl. bulk petroleum marine terminal in South Norfolk, Va. Terminal, including product storage tanks, pier loading racks, warehouse and office facilities, is scheduled for completion by the fall.

Goodyear Tire & Rubber Co. announces plans for construction of a $20-million rubber plant, to be built at an undisclosed site on the Gulf Coast.

Houndry Process Corp. officials place on stream their new unit for manufacture of urethane-foaming catalyst at Paulsboro, N. J. Rising demand for foamed urethane spurred the capacity boast.

U B S Chemical Co., Cambridge, Mass., will soon start up new polymer-emulsions capacity at Lemont, Ill. UBS markets polystyrene and acrylic emulsions to floor polish and paint industries.

B. F. Goodrich Chemical Co. announces plans for construction of a polyvinyl chloride plant at Watson, Calif. Goodrich recently awarded Scientific Design Co., Inc. a con-

FOLLOW THIS MAN!

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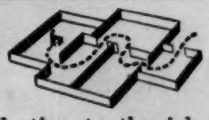
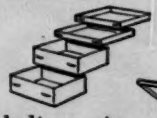
Up a stairway on a hurry-up job, nothing to it with the big, 10-inch diameter, semi-pneumatic balloon tires. Emergency repair work across the plant,  compact Tool Truck carries full tool selection to the job. Job in another building, the Tool Truck eases heavy loads over rough pavements or tracks. Drawers are held shut during travel by a padlocked bar.

The new *Snap-on* Tool Truck is invaluable wherever tools or parts transport is needed. Plenty of tool space with four husky drawers.  Upper panel section is partitioned for nuts, bolts, parts. Ample storage space throughout.

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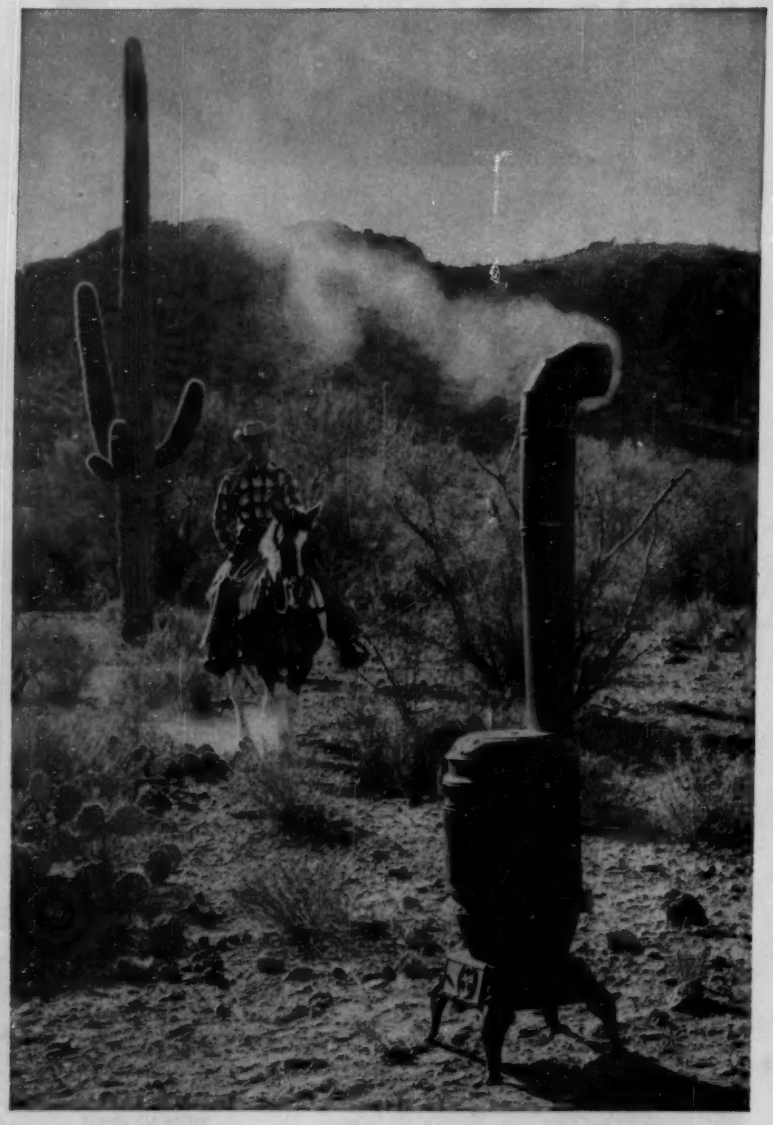

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tract to design and construct the new PVC plant.

Stauffer Chemical Co. plans an expansion of its Nyotex Division's Houston, Tex., aluminum fluoride plant. Stauffer employs its own fluid-bed process for aluminum fluoride production.

Borden Chemical Co. plans construction of a 20,000-ton/yr. polyvinyl chloride plant at Illiopolis, Ill. New plant, to cost near $4-million, will produce PVC and copolymer for flooring, record, coating and specialty resin industries.

Stauffer Chemical Co. has begun construction of a plant for production of xanthate flotation agent, adjoining the carbon disulfide plant of Industrias Quimicas de Mexico, S. A., at Morelia, Mexico.

Susquehanna-Western, Inc. announces plans for construction of a uranium concentrate plant, to be built near Falls City, Tex. Plant, to cost from 2 to 2.5-million dollars, will supply uranium concentrate to the AEC.

OVERSEAS BRIEFS

France: United Carbon Co. announces plans for formation of a French subsidiary and construction of a $5-million carbon-black plant near Rouen, France. New plant, to be completed early next year will have a rated capacity of 50-million lb./yr.

India: Koppers, Inc., Pittsburgh, Pa., is negotiating with the Indian Government for a contract to construct and operate a fertilizer chemical plant at Rajasthan.

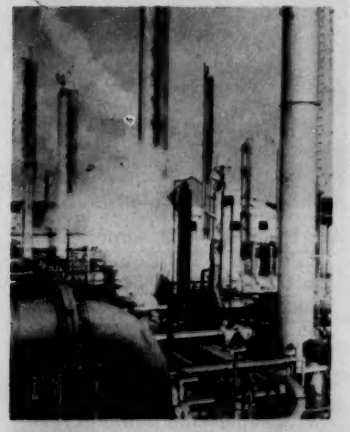
India: Construction has begun of Mandya National Paper Mills, Ltd., in Mysore State. New paper mill will produce

35 tons/day of high-grade writing and printing papers from sugar cane bagasse pulp.

Italy: Shell Oil Co. announces plans for addition of a 100,000-ton/yr. aromatics extraction and fractionation plant at its Rho refinery near Milan.

Netherlands: Dow Chemical International, Ltd., S. A., is constructing a styrene-butadiene latex plant in Rotterdam. Plant to cost $2-million, is scheduled for completion by spring of 1961.

Witco Chemical Co. tightens its hold of the tar products market, has acquired the Tar Distilling Co., Inc., and Old Colony Tar Co., Inc. Tar Distilling Co., Cleveland, Ohio, produces creosote oil, pitch and naphthalene; Old Colony Tar Co. produces tar-paving material in four plants in Massachusetts.



Jefferson Chemical Co. has purchased the Conroe, Tex., plant of Gulf Oil Corp. Jefferson takes over the plant's seven automatically controlled process units, control laboratory, shipping and receiving facili-

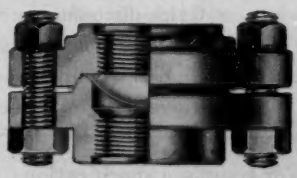
Tranquilizer... made of metal

You don't swallow this "tranquilizer"... but it can bring you priceless peace of mind! It's the rupture disc in a BS&B Safety Head—one of thousands upon thousands that protect personnel and equipment against dangerous pressure build-ups in vessels and lines containing air, gases or liquids.

When pressures rise above predetermined safe limits, this disc ruptures to provide instantaneous, unrestricted relief. BS&B designs discs to rupture at any specified pressure from 3 to 100,000 pounds per square inch. They are supplied in sizes ranging from ⅜-inch to 36 inches diameter, and in special sizes to virtually any specification.

BS&B SAFETY HEADS protect pressure systems in every type of industry

Thousands of BS&B Safety Heads have been in use for the past 26 years in virtually every type of industry where pressure protection is a problem. If your responsibility includes the *safe* operation of pressured systems in your plant, why not let us tell you more about BS&B Safety Heads?



BLACK, SIVALLS & BRYSON, INC.

manufacturers of diaphragm valves, controllers, regulators, safety heads.
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New pressure controls . . . 0.5 to 150 psig.

Diaphragm Pressure Regulators

. . . with PLUS-PERFORMANCE FEATURES

Now . . . Robertshaw engineers answer still more of your pressure control problems with these highly efficient diaphragm-actuated companions to our famous *bellows* self-ops!

Ruggedly built and modestly priced, this new 1065 Series is offered in four diaphragm sizes, with nine different ranges from 0.5 to 150 psig. Single-seated ½" to 2" valves for positive shut-off . . . piston-balanced in the larger sizes; double-seated, 2½" to 4" sizes.

- **Nylon-reinforced, moulded Buna-N diaphragm**
- **Spring-loaded Teflon chevron lifetime packing**
- **Ball-bearing wheel adjustment**
- **Quick-disconnect, polished monel valve stem**
- **Stainless steel trim standard**
- **Highest quality chrome steel adjusting spring**
- **Valve designs backed by years of field service**

For complete specifications, ask for Bulletin EC-125. **Fulton Sylphon Division, Robertshaw-Fulton Controls Company, Knoxville 1, Tennessee.**

Robertshaw®

MR. CONTROLS

ties, boilers, cooling towers and offices. Included in plans for the future are manufacture of morpholine, intermediates for the urethane industry, intermediates for rubber manufacture and corrosion inhibitors.

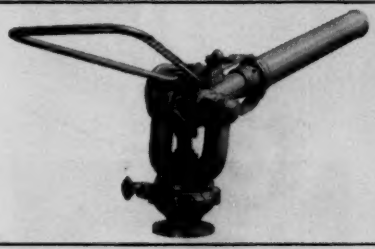
Air Products, Inc. supplies its millionth ton of liquid oxygen to the U. S. Air Force to keep missiles soaring into space. Shown above is frost flaking of an ICBM Atlas as the engines begin operation; frost forms as Atlas is charged with super-cold liquid oxygen.

Philco Corp. has formed a separate Computer Division with headquarters near Willow Grove, Pa. Heavy orders for Philco's computer spurred the organizational change.

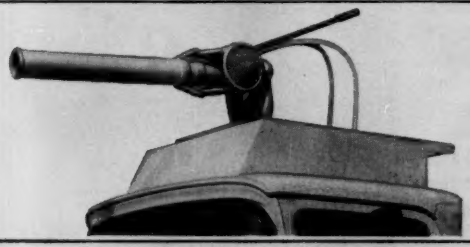
Most Complete Line of Specialty Turrets on the Market!

...All Rockwood Turrets Discharge FogFOAM
Solid FOAM Stream — WaterFOG — Solid Water Stream

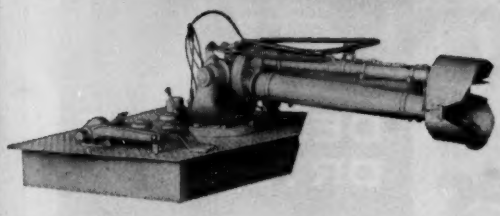
Extended Manual Control Type — Turret nozzles extend 10 to 20 feet above remote control station on deck or ground on standard units . . . greater remote extensions for special applications.



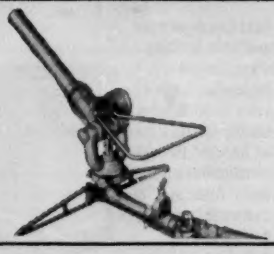
Direct Manual Control Type — Gives fire fighters "out-in-the-open" control from cab roof!



Remote Manual Control Type — Easily handled by man in driver's seat. Ideal for fast action!



Remote Hydraulic Control Type — Power-controlled from within the cab. Single and dual models. Widely used on air crash rescue fire-fighting trucks.



Portable Type — Off the truck and into action in seconds! Goes wherever a fire fighter can bring the proper hose line into action!

On the truck or on the ground, fire fighters can hit fires *harder* using ROCKWOOD Turrets! At airports and refineries . . . in municipalities and throughout industry . . . these advanced-design fire-fighting aids are constantly proving their ability to extinguish fires faster.

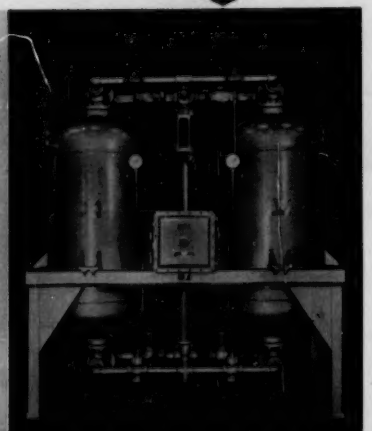
ROCKWOOD Turrets provide plenty of volume *and* versatility. What's more, all are easily adjustable on the fire line to meet changing fire conditions. Produced by the world's largest manufacturer of specialty Fire-Fighting Turrets, they're designed to give fire fighters an extra edge of efficiency on most types of fires. Get full details on the complete line of fire-fighting products. Write ROCKWOOD SPRINKLER COMPANY, Portable Fire Protection Division, 529 Harlow Street, Worcester 5, Massachusetts.

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
Engineers Water ... to Cut Fire Losses
Distributors in all principal cities.

REDUCE MAINTENANCE COSTS

Moisture and oil in your air system will result in costly repairs, down time, and even system failure. Moisture causes rust that clogs delicate sensing devices, slows down pneumatic controls, and in some cases, brings about total destruction of expensive equipment. Random oil in an air system forms sludges, gums and hard varnishes, causing instrumentation and control breakdown.

TRINITY



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Heat-Les

The Trinity Heat-Les dryer makes possible the driest air of all. This amazing dryer is being used in hundreds of industrial and military installations, and establishing new records for dependability, economy and performance.

- Dewpoints to -200°F.
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- No increase in air temperature.

Heat-Les dryers are available in many sizes, for all pressures, from 1 scfm to 5000 scfm. Larger volumes may be handled through combinations of units. Also, in complete, unitized dry air systems, including compressor, accumulator and instrumentation.

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World leader in dry gas systems

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CALENDAR

Instrument Society of America, Temperature Measurement Symposium, Deshler-Hilton Hotel.
March 9-11 Columbus, Ohio

Instrument Society of America, Temperature Symposium, Deshler-Hilton Hotel.
March 9-11 Columbus, Ohio

The Fiber Society, spring meeting, Roosevelt Hotel.
March 10-11 New Orleans, La.

American Institute of Chemical Engineers, Sabine Area Section—American Chemical Society, Texas Louisiana Gulf Section, annual joint technical meeting, Lamar State College of Technology.
March 11 Beaumont, Tex.

American Concrete Institute, annual convention, Commodore Hotel.
March 14-17 New York, N. Y.

National Assn. of Corrosion Engineers, 16th annual meeting, Memorial Auditorium.
March 14-18 Dallas, Tex.

Institute on Industrial Relations, annual meeting, Hollywood Beach Hotel.
March 14-18 Hollywood, Fla.

Colorado Mining Assn., national Western Mining and Energy Conference, Hilton Hotel.
March 17-19 Denver, Colo.

Institute of Radio Engineers, national convention, Waldorf Astoria Hotel & New York Coliseum.
March 22-24 New York, N. Y.

Oil Trades Assn. of New York, meeting, Waldorf Astoria.
March 23 New York, N. Y.

New England Gas Assn., annual meeting, Statler-Hilton Hotel.
March 24-25 New York, N. Y.

Textile Research Institute, annual meeting. Hotel Commodore.
March 24-25 New York, N. Y.

Material Handling Institute, Inc., Pittsburgh Hilton Hotel.
March 28-29 Pittsburgh, Pa.

Western Petroleum Refiners Assn., annual meeting, Hilton Hotel.
March 28-30 San Antonio, Tex.

American Institute of Chemical Engineers, Philadelphia-Wilmington Section, all-day meeting: Separation Processes, University of Pennsylvania.
March 29 Philadelphia, Pa.

American Power Conference, sponsored by Illinois Institute of Technology Hotel Sherman.
March 29-31 Chicago, Ill.

American Society of Mechanical Engineers, Power Conference, Sherman Hotel.
March 29-31 Chicago, Ill.

American Oil Chemists Society, meeting, Baker Hotel.
April 3-6 Dallas, Tex.

Nuclear Congress, sponsored by Engineers' Joint Council and Engineering and Scientific societies, New York Coliseum.
April 3-8 New York, N. Y.

American Oil Chemists Society, annual meeting.
April 4-6 Dallas, Tex.

American Management Assn., National Packaging Exposition and Conference, Convention Hall.
April 4-7 Atlantic City, N. J.

Instrument Society of America, New Jersey Section, all-day symposium: Computers in the Process Industry, Essex House.
April 5 Newark, N. J.

Building Research Institute, Paints and Coatings Conference, Statler-Hilton Hotel.
April 5-7 New York, N. Y.

Building Research Institute, Paints and Coatings Conference, Statler-Hilton Hotel.
April 5-7 New York, N. Y.

Instrument Society of America, National Chemical and Petroleum Symposium, Sheraton Hotel.
April 5-7 Rochester, N. Y.

American Society of Mechanical Engineers-Society for Advancement of Management, Management conference, Statler-Hilton Hotel.
April 7-8 New York, N. Y.

Management Seminar, sponsored by Cornell University, fee: $900, Statler Inn, Cornell Campus.
April 13-26 Ithaca, N. Y.

American Society of Mechanical Engineers-Institute of Radio Engineers-American Institute of Electrical Engineers, third annual conference on Automatic Techniques, Cleveland-Sheraton Hotel.
April 18-19 Cleveland, Ohio

Stanford Research Institute, Symposium: Chemical Reactions in the Lower and Higher Atmospheres, Mark Hopkins Hotel.
April 18-20 San Francisco, Calif.

American Society of Lubrication Engineers, annual meeting and exhibit, Netherland-Hilton Hotel.
April 19-21 Cincinnati, Ohio

Oklahoma State University, heat-transfer conference.
April 20-22 Stillwater, Okla.

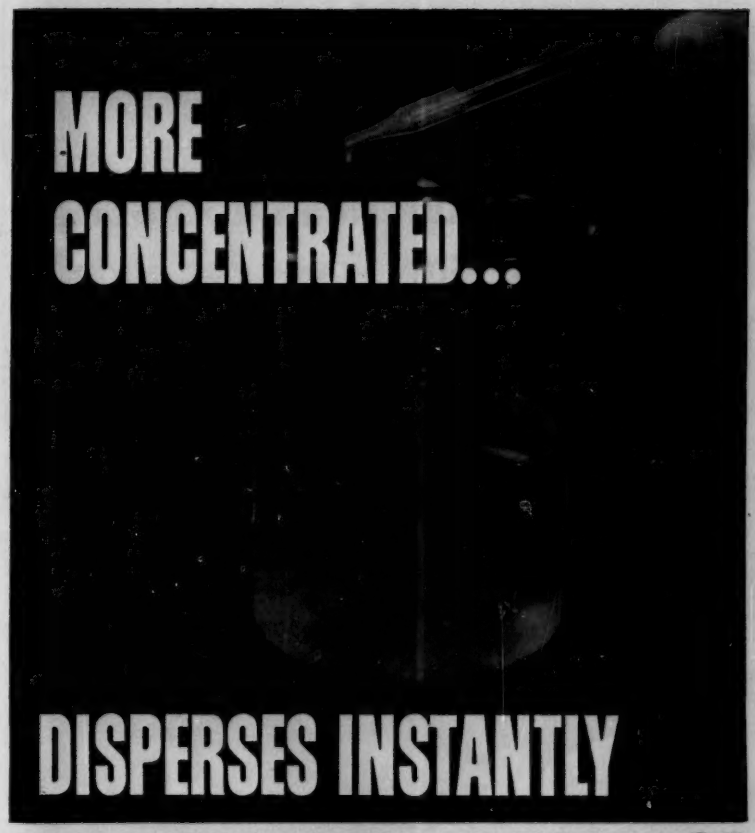
National Petroleum Assn., semi-annual meeting, Cleveland-Sheraton Hotel.
April 20-22 Cleveland, Ohio

Instrumentation for the Process Industries, symposium sponsored by Texas A. & M.
April 20-22 College Station, Tex.

German Industries Fair, Hanover Fair Grounds.
April 24-May 3 Hanover, W. Germ.

Society of the Plastics Industry, annual Canadian Section conference, London Hotel.
April 25-26 London, Ont.

American Society of Mechanical Engineers, Maintenance and Plant Engineering Conference, Chase-Park Plaza.
April 25-26 St. Louis, Mo.



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More concentrated: General Electric Anti-Foam 60 comes to you in concentrated form (30% silicones) for easier handling and storage. You can use it as supplied, or reduce it with water to any desired concentration.

Disperses instantly: G-E Anti-Foam 60 can be poured and disperses instantly because of its low viscosity. This makes it easier to use and faster-acting than other silicone defoamers.

More economical: Only a few parts per million are needed in most foaming systems, even less than other silicone anti-foams. And because such minute quantities are used, G-E Anti-Foam 60 does not affect the other properties of your formulation, as organic defoamers are apt to do. Write for a free sample.

How G-E Anti-Foam 60 saves you money . . .

1 ppm defoams vat dyes
5 ppm defoam paper sizes
25 ppm defoam resin finishes
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MAIL THIS COUPON FOR FREE TEST SAMPLE:

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Please send me a free sample of G-E Anti-Foam
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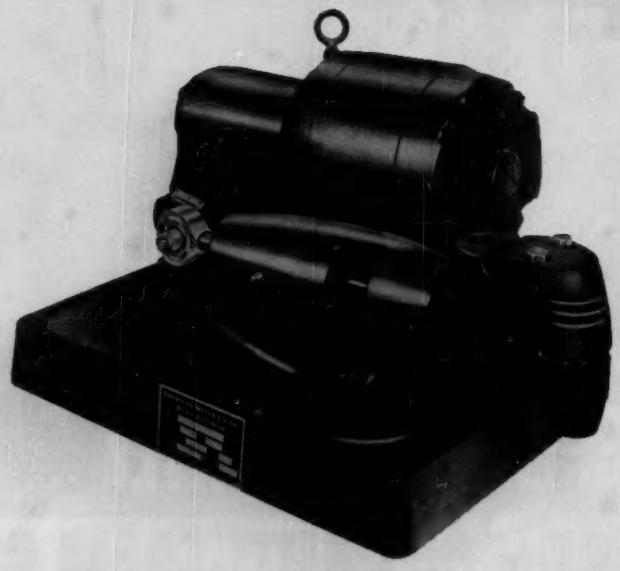
American 200 Series Chemical Feed Pumps



• METERING ACCURACY OF ±1%

• CAPACITY TO 1624 GPH.

New 200 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi.

Easy, inexpensive operation is assured by these quality features:

- Self-contained lubrication system—no downtime for lubrication.
- E-Z Clean Cartridge Valves simplify maintenance.
- Interchangeable liquid ends for greatest adaptability in the field.
- Precision screw adjustment on crank for easy accurate stroke regulation.
- Sealed Self-aligning bearings on crank and crosshead withstand greater radial and axial thrust loads.
- Crossheads of hardened and ground steel ride on cast iron.
- Heavy duty reducers.
- NEMA frame motors.

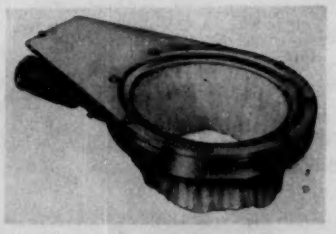
Precision built 200 Series pumps handle a wide variety of "tough," corrosive materials. In Chemical Processing, Refining and Boiler Feed operations, the pumps assure highest accuracy in feeding precisely metered fluids in virtually all ratios, with flow, temperature, pressure, conductivity, PH and other controlled process variables.

Write today for more information.

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1836
pump division
13500 PHILMONT AVE. PHILADELPHIA 16, PA.

(*Continued from page* 86)

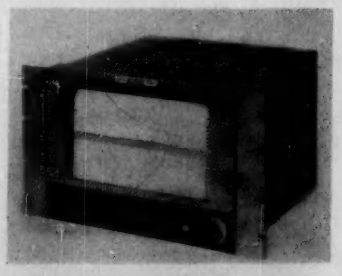
available for special applications where axial movement must be permitted, but these devices do not absorb axial pressure thrust. Joint sizes range from 3 to 72 in. nominal diameter.—**Zallea Bros., Wilmington, Del.** **86D**



Bulk-Solids Valve

Motor controls size of iris-type aperture.

Syntron's motorized Iris Flow control valve enables pushbutton positive control for flow and shutoff of bulk materials from bins, hoppers and chutes. The electric motor drive and remote control enables valve installation in locations inaccessible to manual operation. Principal feature of the valve is a flexible diaphragm that forms a constant aperture that varies in size to form a countless number of openings. Design permits holding of valve position against required head load of bulk material.—**Syntron Co., Homer City, Pa.** **178A**



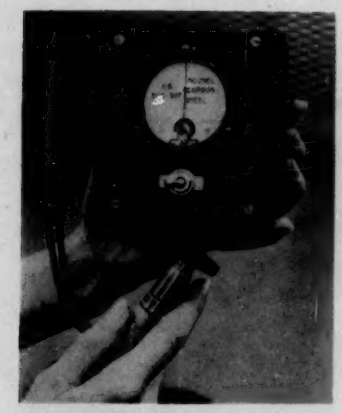
Strip-Chart Recorder

Quick speed change, high accuracy are features.

A new strip-chart recorder that provides instant selection, through transistor switching,

of six chart speeds claims a full-scale sensitivity of 0.05%, and a resolution and accuracy of 0.2%. The six chart speeds (2, 4, 6, 8, 15 and 60 in./min.) can be selected instantly via front-panel pushbuttons. All other function controls mount conveniently on the panel.

Called Model 80A, the unit has an input range of 5 mv. to 100 v.; the range is covered in 10 steps, or by vernier for completely continuous span voltage control. Chart roll size is 120 ft.—F. L. Moseley Co., Pasadena, Calif. 178B

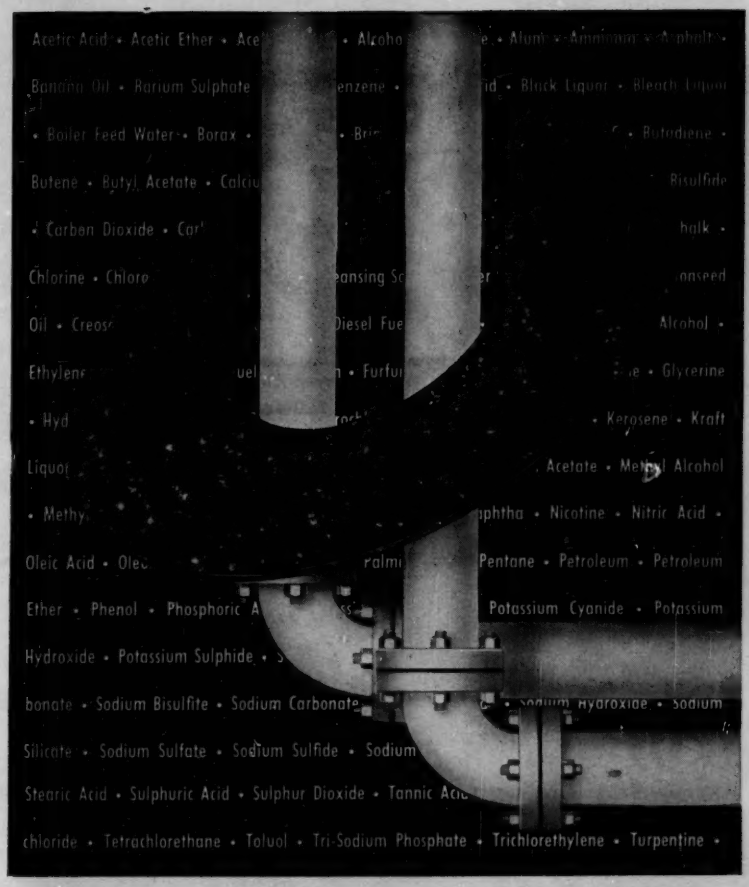


Metal Sorter

Quickly differentiates between nonmagnetic metals.

Without special training, plant personnel can use a unique device to differentiate between Inconel and stainless steel, Zircaloy-2 and zirconium, and Zircaloy-2 and hafnium, without time-consuming, complicated testing. The device consists of a standard milliammeter with two leads, one ending in a clamp and the other in a small carbon-steel file. Test procedure involves attachment of clamp to, and rubbing of file briskly against, the metal having dubious identity.

Friction between the file and test sample causes a localized hot spot. This hot junction produces a readily measurable current as a result of the thermoelectric effect—the polarity of stainless steel is different from the polarity of Inconel with re-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Oil • Creos Diesel Fue Alcohol •
Ethylene • Furfu • Glycerine
• Hyd • Kerosene • Kraft
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Silicate • Sodium Sulfate • Sodium Sulfide • Sodium
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ONE GASKET MATERIAL

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DURABLA Homogeneous Compressed Asbestos Sheet Packing is a single-formula material that can be used with proved safety for the sealing of practically all oils, gases, alkalies, acids and hydrocarbons. It is suitable for a wide range of temperature-pressure combinations.

The versatility of this material results from the use of a greater percentage of selected Canadian asbestos fibre, of the spinning group, than is found in any other gasket material. The asbestos is skillfully compounded with a special binder. Every square inch of the sheet has uniform density, thickness and asbestos distribution.

DURABLA Sheet Packing is available in eight different gauges. Gaskets are supplied in all sizes and shapes, accurately machine cut.

Write for full information about *the* all-purpose gasket material. Ask for a copy of bulletin CE 30

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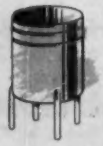
DOES IT BETTER for MIXING COOKING COOLING...

Whether your specific need is for more efficient mixing; faster, even cooking temperatures, or quick cooling of cooked material, Groen equipment *does it better.*

Steam-jacketed agitating type kettles heat up faster—save time. Provide more thorough mixing and controlled cooling.

New stainless steel steam-pressure cooker in standard models or special sizes.

Stainless steel jacketed reactors.



Complete line of stainless steel tanks in vertical and horizontal designs.

GROEN ALSO MAKES: Vacuum pans; Coils; Coating pans; Filters; Tubular heat exchangers; Pilot plant processing units; Custom equipment. Write for engineering catalog.

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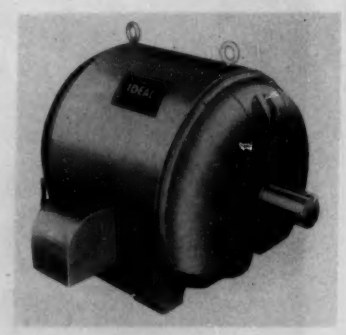
spect to carbon steel, etc. Current output is a function of the test metal. — **General Electric Co., Schenectady, N. Y. 179A**



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Dripproof models offered for high-speed service.

New, high-speed, squirrel-cage induction motors are now being offered in 100-5,000 hp., 514-3,600 rpm., frames 584-11320 for all high-speed applications.

A one-piece, wrap-around steel plate cover, running the full length of the frame, extends well below the motors' centerline on each side to provide natural dripproof protection, and to increase rigidity of the frame structure. Double-end ventilation system provides maximum cooling. Insulations include silicon rubber as well as Class A, B and H types.—**Ideal Electric & Mfg. Co., Mansfield, Ohio. 180A**

Motor Control Centers

Offer easier maintenance, increased versatility.

Motor control centers with bus capacity from 200 to 2,000 a. for voltages from 110 to 600 are available either as fusible or circuit-breaker combination units. Each unit consists of two or more starters, fed from a common bus, and often attached to a transformer or switchgear to form a unit substation.

Outstanding features include reduced engineering and installation costs, floor-space savings

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MACON, Ga., Industry Insulation Co.
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MEMPHIS, Tenn., John A. Denie's Sons, Co.
Gibbons Supply Co.
MIAMI, Fla., Reynolds Aluminum Supply Co.
Southern Metal Products Co.
MILWAUKEE, Wisc., F. R. Dengel Co.
MINNEAPOLIS, Minn., Asbestos Products, Inc.
MOBILE, Ala., Shook & Fletcher Insulation
MONTGOMERY, Ala., Shook & Fletcher Supply
MOORHEAD, Minn., Fargo-Moorhead Insulation Co.
NASHVILLE, Tenn., Reynolds Aluminum Supply Co.
NEWARK, N. J., Eastern Steam Specialty Co.
NEW ORLEANS, La., Eagle Asbestos & Packing Co.
NEW YORK, N. Y., Eastern Steam Specialty Co.
ODESSA, Tex., Western Chem. & Supply
OKLAHOMA CITY, Okla., Ball Distributing & Engr. Co.
OMAHA, Nebr., Cardinal Supply & Mfg. Co.
ORANGE, Conn., Insulation Supply Co.
PADUCAH, Ky., Triangle Insulation Co.
PHILADELPHIA, Pa., John F. Scanlan, Inc.
PHOENIX, Ariz., Kircher Asbestos & Rubber Co.
PITTSBURGH, Pa., Keystone Div. of Dravo Corp.
PORTLAND, Me., Eastern Glass Co.
PORTLAND, Ore., Western Fibrous Glass
RALEIGH, N. C., Reynolds Aluminum Supply Co.
RAPID CITY, S. D., Robbins & Stearns Wholesale
RICHMOND, Va., Reynolds Aluminum Supply Co.
ROANOKE, Va., C. E. Thurston Co.
ROCKFORD, Ill., Mott Brothers Co.
SALT LAKE CITY, Utah, Bullough Asbestos Sup. Co.
SAN ANTONIO, Tex., San Antonio Machine & Supply Co.
SAN DIEGO, Calif., Western Fibrous Glass Prod. Co.
SAN FRANCISCO, Calif., Western Fibrous Glass Prod. Co.
SAVANNAH, Ga., Reynolds Aluminum Supply Co.
SEATTLE, Wash., Western Fibrous Glass Products Co.
SHREVEPORT, La., Frith Sales Co.
SOMERVILLE, Mass., Insulation Products, Inc.
ST. LOUIS, Mo., The Stovey Company, Inc.
ST. PAUL, Minn., Asbestos Products, Inc.
SULLIVAN, Ill., Lewie David, Inc.
SYRACUSE, N. Y., Burnett Process, Inc.
TAMPA, Fla., Eagle Roofing & Art Metal Works, Inc.
TULSA, Okla., Ball Distributing & Engr. Co.
TUPELO, Miss., Paine Supply Co.
WASHINGTON, D. C., Walter E. Campbell Co., Inc.
WEST PALM BEACH, Fla., Southern Metal Prod.
WICHITA, Kans., General Metals, Inc.

Insulation Contractor: Precision Insulation Co., Houston

"30% saving on handling and wastage alone . . . with G-B SNAP*ON®"

This experience of an insulation contractor highlights one of the many advantages of G-B SNAP*ON, the original one-piece pipe insulation molded of fine glass fibers:

*"When we recently installed about two miles of G-B SNAP*ON and a rigid type insulation, we had a good opportunity to compare the two. Much of the job required dragging insulation through wet, muddy crawl spaces. The way G-B SNAP*ON stood up under this abuse, with practically no waste, convinced me it is the ideal pipe insulation. We figure we saved 30% on handling and wastage alone by using G-B SNAP*ON."*

Featherweight 3′ and 6′ sections of G-B SNAP*ON also cost less to apply! "SNAP"—and the pipe is covered, even in tight spots and close quarters. So outstanding is its thermal efficiency that 1½″ G-B SNAP*ON is thermally superior to most 2″ insulations—more permanent, too. For your next pipe insulating job, be it large or small, hot or cold, specify G-B SNAP*ON and discover its many outstanding features for yourself!

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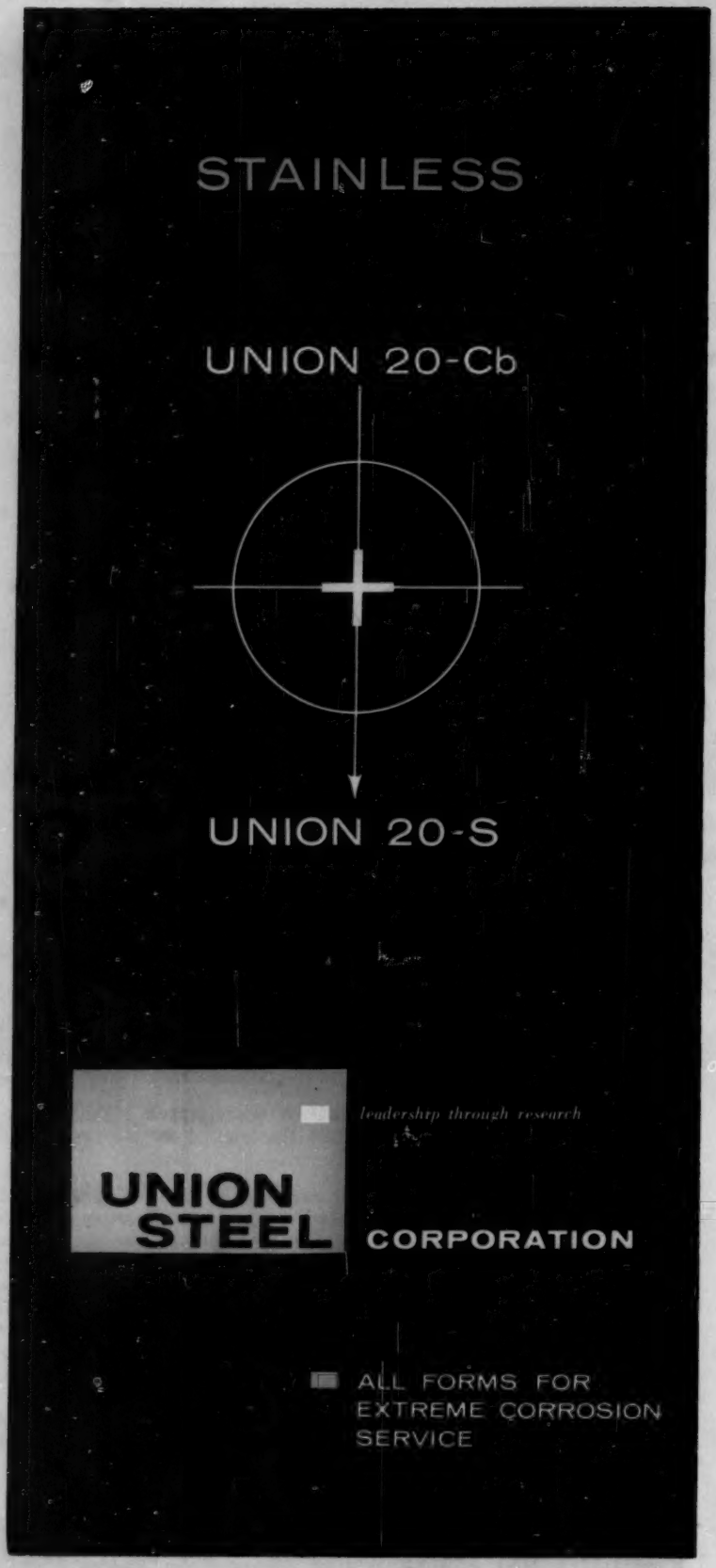
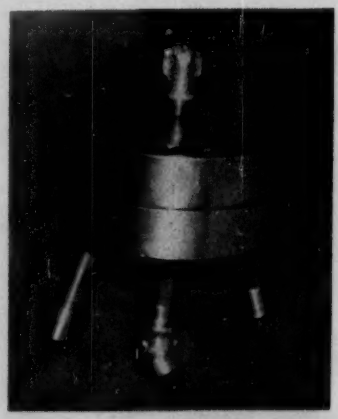
Thermal and acoustical glass fiber insulations . . . Molded glass fiber pipe insulation
Couplings and fittings for plain and grooved end pipe



to 33%, versatility through plug-in design, and neat equipment arrangement.—**The Allis Chalmers Mfg. Co., Milwaukee, Wis.** **180B**



Manifold Valve

Controlling fluid may be either liquid or gas.

Having only one moving part, a new differential-pressure manifold valve actuates under influence of air, gas or other fluid on the control side. The working side can handle the same or other gases, fluids and slurries. In operation, the valve can divide flow of entering fluids two to six ways. Or, the unit may find use in mixing operations where two or more fluids enter and must leave through a common exit.

Fast response, quiet operation and economical installation are claimed features. Port sizes range from ⅛ to ½ NPT on both control and working sides. Materials of construction include aluminum, brass, nylon, Teflon resin and stainless steel. —**Frankel Engineering Laboratories, Inc., Reading, Pa.** **182A**

Pressure Control

Air-adjusted pilots claim high sensitivity.

Control accuracies to within ½ psi., from positive pressures through the vacuum range to 30 in. Hg, are standard with a new series of air-adjusted pressure

OK Flow Sheet

HOKE REPORTS ON FLUID CONTROL

A VALVE NAMED "DESIRE"

With apologies to Tennessee Williams, we really have produced a Solenoid Valve line based on *your* desires. We surveyed all the solenoid valve users we could find to determine what *you* wanted. The result is Hoke's "User Designed" Series 90 and 95, two-way and three-way, direct-acting solenoid valve line.

Thanks to you, we have much to brag about. Here's what we have been saying about these new valves: lightest weight – smallest size – no-hum operation – lowest temperature rise – lowest power consumption – stainless steel plunger – silver AC shading coils – easiest installation – packless construction – 360° rotatable housing – operates in any position.

We make them of forged brass or stainless steel, in ⅛" and ¼" NPT size or JIC tube ends. There's a variety of AC and DC voltages. Class "A" coils are standard, but Class "H" are also available for temperatures above 212°F. For those with high insurance rates, we can supply explosion proof coil housings.

Now that we've bragged a bit, we must also apologize for our premature enthusiasm. We were so excited about this product that we stirred up a hornet's nest of interest before we were ready to deliver in quantity. Shipments were slow at the start, but now we can have any reasonable quantity of these "desirable" solenoid valves "on-stream" in your plant when you want them.

There's only one way to get conclusive performance proof – buy a valve. Ask for Bulletin SV-1159.

What Goes With What?

This is a question engineers and chemists are constantly asking each other. Not that we want to do away with this healthy interplay at the water cooler, but we have put together a slide rule that answers all these questions. It lists 22 metals and materials and their degree of resistance to 247 corrosive agents.

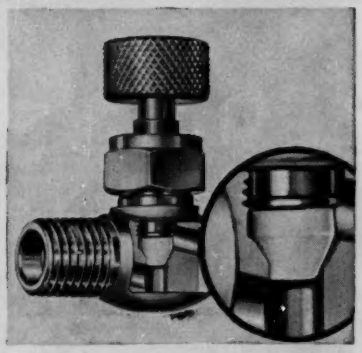
Got yours? Write now while there are a few (thousand) left.

HOKE'S NEW PLASTIC STEM TIPS END CHRONIC FAILURE PROBLEM

Galling and scoring valve seats plagued valve users and manufacturers for years, until somebody thought of using plastic stem points. This idea worked well at low pressures, but when the pressure increased – poof! – the valve blew its tip. Up to now, this problem had continued to bother valve makers.

Fortunately, a die-hard Hoke engineer insisted he could put a permanent plastic tip on a high pressure valve. We gave him his head and he gave us a plastic-tipped valve-stem (using either Kel-F or Nylon). His unique design incorporates a crimped metal shell that grabs the plastic tip and *really* holds!

Not satisfied with this monumental accomplishment, he proceeded to tackle leak problems at the stem packing. He put an O-ring seal on the stem and compressed it with a newly-designed Nylon collar. The collar serves a dual role, for it also prevents grit and other foreign matter from chewing up the O-ring. Valves of this new design have performed successfully up to 3500 psi. Our die-hard engineer not only

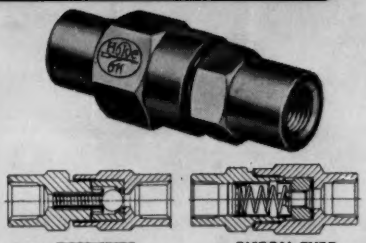


ended galling, but also seat leakage, stem leakage and wear problems – all at one swoop.

There's only one feature about this new development that worries us–since we do not expect replacements we may have designed ourselves right out of the valve business! We make these little dandies of either forged brass, bar stock or 316 Stainless, with ⅛" and ¼" male connections. Temperature limit is 400°F. For the complete story, write, wire, phone or we'll come see you.

Hoke "TECH-SPEC"

570 SERIES CHECK VALVES



BALL TYPE PISTON TYPE

Designed for gas or liquid service at pressures to 5000 psi. Ball and piston types for extremely effective leak-tight closure, coupled with minimum flow resistance. Ball types in ⅛" and ¼" sizes; piston types in ⅜" and ½" sizes. Temperature limits, –40 to 200°F. Body materials are Brass or 303SS. End construction is interchangeable with any combination of inlet and outlet connections. O-ring seals are available.

HOKE, INCORPORATED
39 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Plastic Stem Tips
- ☐ Solenoid Valves
- ☐ 570 Series Check Valves
- ☐ FREE Corrosion Slide Rule
- ☐ Have a salesman call

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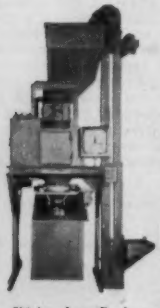
COMPANY_____
ADDRESS_____
CITY_____STATE_____

If you overweigh you lose money...
If you underweigh you lose customers!

Richardson Automatic Bagging Scales are the answer to this problem. They provide high speed bagging with accuracy that eliminates give-away of product, avoids customer complaints of shortweights. Higher production speeds mean reduction in costs, too.



The Richardson E-50 Bagging Scale gives you all these benefits –

Accuracy – within 1 ounce at speeds of ten or more 50-lb. bags per minute!

Versatility – handles weighings from 5 to 200 lbs. of grains, plastics, powdered and granular chemicals, feeds and meals, pellets, sugar, salt, and many others.

Dependability–ruggedly-built for years of trouble-free service.

For full details on the Richardson E-50 and other bagging scales write today.

Richardson Scales conform to U.S. Weights and Measures H-44 for your protection.

Here's the answer...

Richardson

MATERIALS HANDLING BY WEIGHT SINCE 1902

1790

RICHARDSON SCALE COMPANY • CLIFTON, NEW JERSEY

Sales and Service Branches in Principal Cities • Also manufactured in Europe to U.S. standards

pilots. The pilots may also find use in conjunction with recorder-controllers for control of process temperatures.

Bleeding of air only when settings are being changed assures economical use of adjusting air. Maintenance and repair time is kept to a minimum by accessible orifice design. Materials of construction include cast iron, cast bronze and cast steel.—**Spence Engineering Co. Inc., Walden, N. Y.** 182B

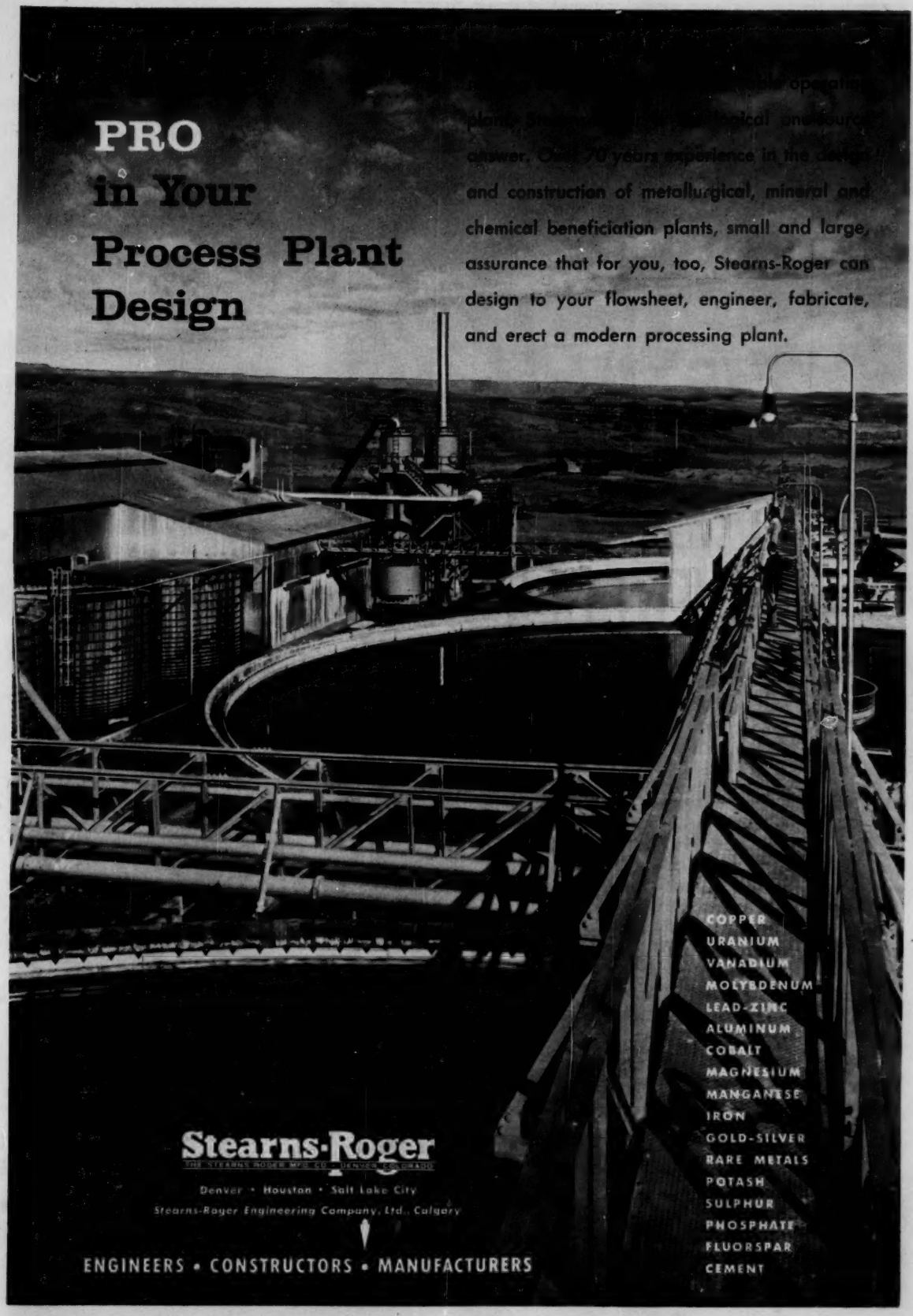
Conversion Unit

For use with electrostatic precipitators.

Consisting of silicon rectifier diodes that are immersed in oil and enclosed in an insulating cylinder, General Electric's new conversion units are offered for use in high-voltage d.c. power supplies on electrostatic precipitators. According to GE, the units will eliminate costly maintenance of mechanical rectifiers and replacement of tube-type rectifiers conventionally used with precipitator systems.

Cost savings from tube replacements and inefficiencies, says GE, will pay for the initial cost of the conversion unit within a relatively short time, depending upon present tube-replacement requirements. Ratings to 75,000 v. RMS, and to 45 kva. in full-wave bridge rectifier circuits.—**General Electric Co., Schenectady, N. Y.** 184A

New Equipment continues on page 186.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and construction of metallurgical, mineral and
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design to your flowsheet, engineer, fabricate,
and erect a modern processing plant.
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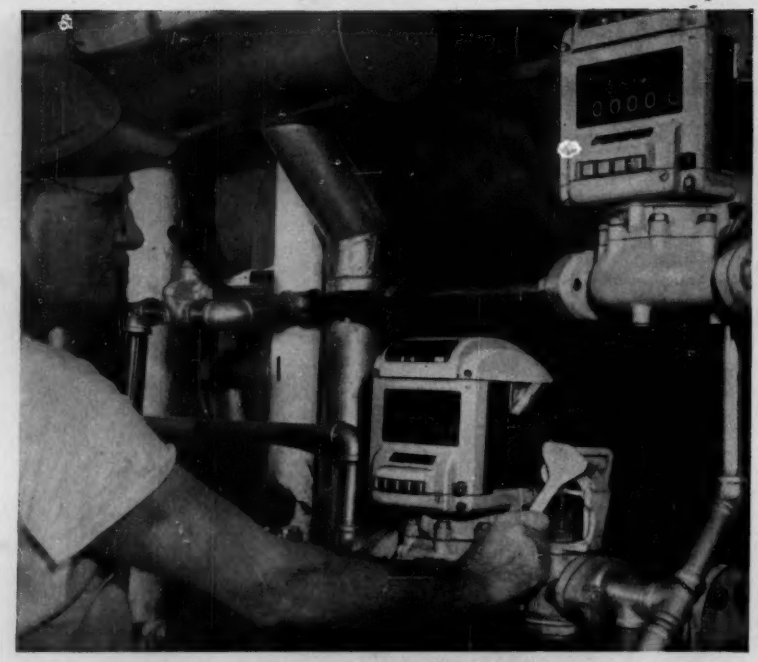


How Textile Mills

PREVENT REJECTS

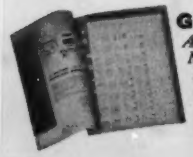
with Neptune Liquid Meters

"Rejects" in weaving dropped way down when Cannon Mills installed Neptune Auto-Stop meters to measure the *exact* amount of water into the warp size mix. Warp size is a mixture of starch, tallow and water. If it's too thick the starch "balls up" on the warp; too thin and the warp is too limp.

Uniformity of warp size was so improved when the first meter replaced the inaccurate dip-stick that *additional* Neptunes were installed throughout all Cannon Mills for warp size control.

Most common liquids are now being measured by Neptune meters... hot or cold water, oils, syrups, brines, soap solutions, chemicals... in hundreds of plants.

Available with Auto-Stop feature to deliver preset quantity of liquid; with Auto-Switch to operate pumps, valves, etc.; and with Print-O-Meter register to give a dispute-free record of each batch. Capacities: 2 to 1000 gpm. in bronze; 20 to 100 gpm. in stainless steel. Send for Meter Application Bulletin 566-A



GET THE FACTS

Ask for helpful Meter Data Bulletin 566 A See Neptune Data Pages in Chemical Engineering Catalog.

NEPTUNE METER COMPANY

19 West 50th Street • New York 20, N.Y.

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NEW EQUIPMENT . . .

Flowmeter

European firm introduces bellows instrument.

For branches of the process industries where mercury-type flowmeters are not recommended, a new, differential flowmeter with bellows movement may prove substantially beneficial. Through elimination of mercury and use of magnetic motion transmission, the new instruments can withstand pressures to 5,700 psi.

In operation, a change in differential pressure between two chambers results in compression or extension of a bellows. Bellows motion transmits to an indicating element, and then to a totalizer magnetic coupling in rack gear. A built-in squaring mechanism relates differential pressure and rate of flow.—**Siemens & Halske, G.m.b.H., Vienna, Austria.** **186A**

Discharge Valve

Peristaltic action permits handling of coarse solids.

Coarse abrasives, such as catalysts, pellets and other odd-shaped materials unable to pass through conventional rotary valves are readily handled by a new rubber-diaphragm peristaltic discharge valve. An elliptical body and "sandwiching" of the sheet-rubber diaphragms assure positive closure.

All movement is confined to the valve's gum-rubber dia-

RUGGEDLY BUILT FOR YOUR TOUGHEST JOBS!

DARNELL
CASTERS AND WHEELS

Built to take it... Indefinitely!

designed to suit your every need

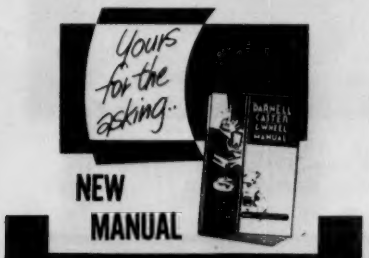
RUBBER TREADS . . . a wide choice of treads suited to all types of floors, including Darnelloprene oil, water and chemical-resistant treads, make Darnell Casters and Wheels highly adapted to rough usage.

RUST-PROOFED . . . by zinc plating, Darnell Casters give longer, care-free life wherever water, steam and corroding chemicals are freely used.

LUBRICATION . . . all swivel and wheel bearings are factory packed with a high quality grease that "stands up" under attack by heat and water. Quick grease-gun lubrication provides easy maintenance.

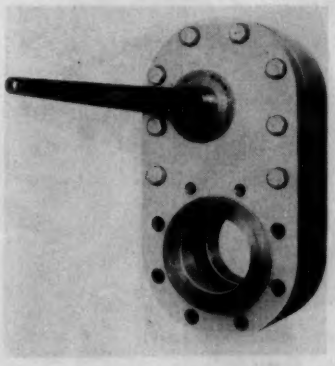
STRING GUARDS . . . Even though string and ravelings may wind around the hub, these string guards insure easy rolling at all times.

Write today for the complete story



DARNELL CORPORATION, LTD.
DOWNEY (LOS ANGELES COUNTY) CALIFORNIA
37-28 SIXTY-FIRST ST., WOODSIDE 77, L. I., N. Y.
36 NORTH CLINTON STREET, CHICAGO 6, ILLINOIS

phrams, which alternately open and close by air pressure or vacuum. This action permits measured discharge with 100% airtight seal. — **U.S. Hoffman Machinery Corp., N. Y. 186B**



Gate Valve

Claimed more compact than most competing units.

Called the G-5, a new, extremely simple and compact valve for general pipeline and manifolding service comes in both lever- and handwheel-operated models. Size extends from 2 to 36 in. in the ASA 150 Series.

For block-and-bleed service, G-5 offers a reduction in hookup costs by eliminating one valve and a spool, previously required in such assemblies. The valve provides a seal on both upstream and downstream sides. **—Grove Valve & Regulator Co., Oakland, Calif. 187A**

BRIEFS

Proportioning pump for automatic control on pH of process water responds to a standard pneumatic control pressure of 3 to 15 psig. In addition to accurate feeding of chemicals in proportion to varying hydrogen-ion concentration, the unit has a dual control feature that enables feeding of chemicals in proportion to a varying flow rate. **—B-I-F Industries, Inc., Providence, R. I. 187B**

Indicating transmitter for low-to-medium pressures can be

in mixing, it's all in the head!

duplex simplex

PREMIER

DISPERSATORS

mixers with the patented "MICRO-SHEAR" head

FEATURE: double shearing • balanced operation at much higher speeds than conventional mixers • high intensity mixing • smaller particle sizes than conventional mixers • lower power requirements • adjustments to control aeration or injection of gases into liquids • slotted head achieves quality dispersion

Think of what these features mean to you

REDUCED PROCESSING and RETENTION TIME!

Contact Premier for complete engineering service on any mixing problem

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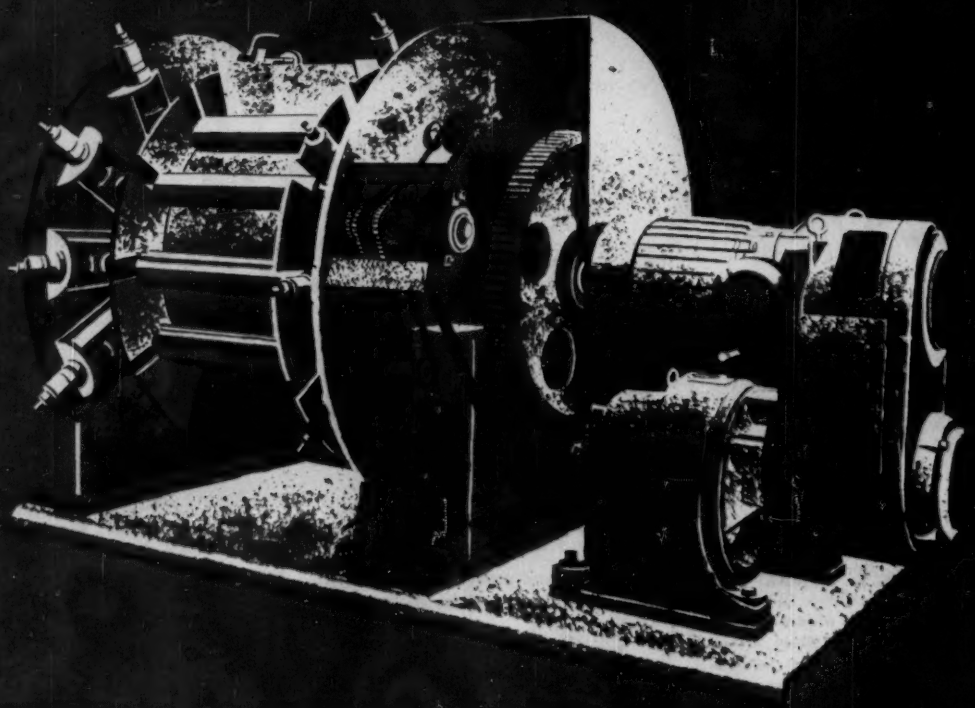
PROBLEM: DEHYDRATION OF POTATOES



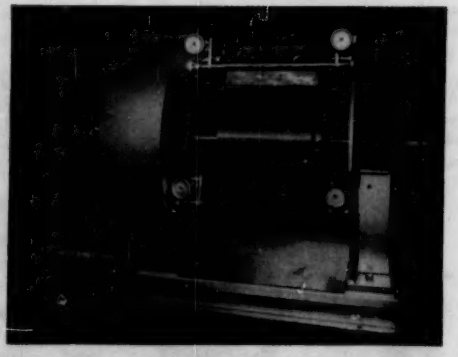
SOLUTION: A DEVINE DRUM DRYER

Still Another Example of Devine Manufacturing Skill

The machine you see above is a Drum Dryer, another fine processing tool from the J. P. Devine drawing board. This customer, as do many on the Devine list, had a special problem. Remember the dehydrated potatoes of World War II? Tasted pretty awful. The customer knew how this problem could be solved. The answer: This standard Devine Drum Dryer using a series of adjustable doctor rolls arranged to roll at the same peripheral speed as the heated drum, which gradually reduces the product to a thin even coating. A doctor knife on the opposite side of the drum flakes off the product, delivering a physically unchanged, easily packaged potato flake with a minimum rupturing of cells.

You may not need a Potato Flaker—or a Drum Dryer either, for that matter—but we think this example shows how J. P. Devine can help you solve your processing problems, enabling you to produce the best product in the most efficient manner.

Other Devine products for the Chemical Processing Industry:
Vacuum Dryers, Blenders and Mixers, Ball Mills, Autoclaves, Paint and Paste Mixers, Agitators, Impregnators, Kettles, Vacuum Pumps, Jacketed Valves, Pipes and Fittings, Code Design and Fabrication.



Rear View 24" Diameter by 18" Face Potato Flaker, Showing Doctor Knife Assembly

J. P. DEVINE MFG. CO.
49th St. & A.V.R.R. PITTSBURGH, PA.

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Write for our new catalog No. 201, with detailed descriptions of our complete line of Drying Equipment.

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located to provide pressure indication at the point of measurement, or within 300 ft., on an easy-to-read dial. In addition, the same unit can simultaneously transmit the pressure measurement electrically to any of the manufacturer's remote-located recorders or indicators. Ranges vary from 0-0.2 in. H_2O to 65 psig.—**Hays Corp., Michigan City, Ind.** 187C

Single-stage compressor of vertical design has piston displacements from 633 to 1,630 cfm. with maximum pressures to 125 psi. and horsepower ratings to 150. Model number is WG-9H.—**Joy Mfg. Co., Pittsburgh, Pa.** 189A

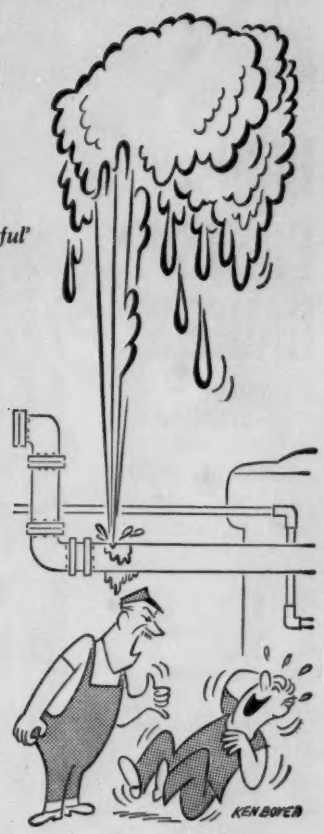
Solids feeder features a 6-in. rotary serrated helix in its body. This component prevents flooding-through, and reduces lumps. An air motor, having an infinite number of speeds, drives the helix. Sizes offered are 9 and 14 in.—**The Fairfield Engineering Co., Marion, Ohio.** 189B

Recorder-controller of round-chart design features an accuracy of ±¼%. Most components are interchangeable with those of existing strip-chart models made by the manufacturer. Minimum accurate scale span for the recorder—a null-balance, potentiometer unit—is 1 mv., d.c.—**General Electric Co., Schenectady, N. Y.** 189C

Porcelainized blower wheels and assemblies that exhibit exceptional resistance to corrosion are offered in sizes from 10 through 20 in., in capacities to 12,000 cfm. Of lightweight construction, the wheels maintain the same run-out and dynamic balance tolerances as standard wheels.—**Morrison Products, Inc., Cleveland, Ohio.** 189D

Seamless vanadium tubing has been successfully extruded in experimental operations at an equipment manufacturer's research and development center. Until recently, vanadium could not be extruded

Life in these excited states...



"Stop saying 'There goes Old Faithful' and get it fixed!"

What to do when corrosion sends costs sky high

No one can afford ruined equipment, endless repairs, and plant shut-downs caused by corrosion. And you *shouldn't* afford *over*-design and too-fancy equipment. Ace takes you right down the middle . . . a wide choice of chemical-resistant pipe, pumps, valves, tanks, etc. Best for the money anywhere . . . backed by 108 years' experience.

TEMPRON *for hot jobs*

Best non-metallic pipe anywhere for *hot* chemicals to 275°F. Also handles tough organics. Rigid, tough nitrile. Pipe and fittings to 8". *Bul. 96A.*

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1001 uses. Non-toxic, odorless, tasteless, sterilizable, flexible tubing. Excellent for chemicals, foods, and for lab or machine lines. ⅛ to 1¼". *Bul. 66.*

"BONDED STORAGE" *for corrosives*

Heavy Ace rubber and plastic tank linings unexcelled for alkalies, acids, bleaches, salts. Faultless seams, indestructible bond, shock and age-resistant. All shapes. *Bul. CE-53.*

DO-IT-YOURSELF PLASTICS

Special equipment often can be machined, punched or welded of standard plastic or hard rubber sheet, rod or tubing. Write for details today.

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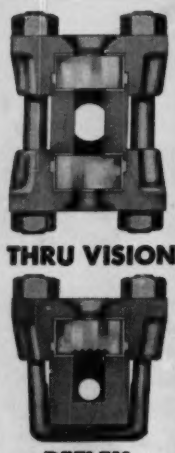
HIGH PRESSURE GAUGES

USED IN REFINERIES AND CHEMICAL PLANTS THROUGHOUT THE WORLD



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Single or Multiple Sections

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Large Chamber Reflex Gauges

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Heated or Cooled Gauges

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NEW EQUIPMENT . . .

because the impure form available was too brittle. Introduction of a commercially pure, ductile form makes the new process feasible.—**Wolverine Tube Div., Calumet & Hecla, Inc., Allen Park, Mich.** 189E

Fluorine analyzer for liquids and solids employs nuclear magnetic resonance techniques. Designated Model 105 Analyzer, the instrument has a precision of 1% of signals; sensitivity is in the 500:1 range. Fluorine peaks that are chemically shifted more than 9 ppm. can be cleanly resolved.—**Ridgefield Instrumentation Div., Schlumberger Well Surveying Corp., Ridgefield, Conn.** 190A

Temperature control valves, in ¼- to 2-in. sizes, feature sliding gate, self-cleaning seats that assure positive shutoff during lockup, and accurate regulation during operation. The piloted units are available for pressures to 250 psi., and temperatures to 500 F. Ten control ranges, from 35-450 F.—**OPW-Jordan, Cincinnati, Ohio.** 190B

Equipment Cost Indexes . . .

	Sept. 1959	Dec. 1959
Industry		
Avg. of all	235.8	237.0
Process Industries		
Cement mfg.	229.9	231.1
Chemical	237.5	239.0
Clay products	223.4	224.6
Glass mfg.	224.2	225.6
Paint mfg.	228.0	228.7
Paper mfg.	228.8	230.2
Petroleum ind.	232.9	233.6
Rubber ind.	235.7	236.5
Process ind. avg....	234.1	235.4
Related Industries		
Elec. power equip...	239.4	242.1
Mining, milling	239.0	240.4
Refrigerating	266.4	267.3
Steam power	223.2	223.9

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124—6 for method of obtaining index numbers; Feb. 23, 1959, pp. 149-50 for annual averages since 1913.

Atlas

PLANT-WIDE PROTECTION STOPS CORROSION!

ATLAS CORROSION-PROOF CEMENTS

. . . complete line of sulfur silicate and resin based cements for plant-wide use in constructing corrosion-proof tanks, floors, pits, trenches and sumps.

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ATLAS RIGID PLASTIC STRUCTURES

. . . corrosion-proof, self supporting polyvinyl chloride designed and fabricated for use as tanks, ducts and fume systems to meet your exact needs . . . plastic pipe systems to convey all your corrosives.

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Write for Bulletin CC-3.

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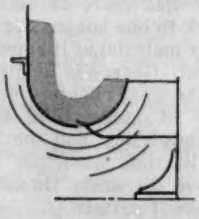
"Q" Factor* Features Available Only in Buffalo Designs

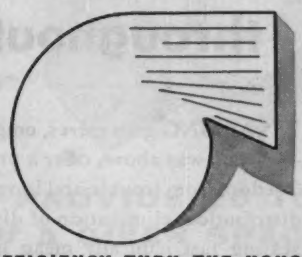


EFFICIENCY AT INLET

Cross-section of inlet, showing smooth half-circle passage into wheel formed by curved inlet bell and mating wheel flange. There are no flat spots to cause turbulence.

EFFICIENCY IN THE WHEEL

Showing deep, backward curve of blades in "BLH" wheel for smooth, quiet handling of air spun into the wheel in the direction of rotation. No waste turbulence.



EFFICIENCY THRU THE HOUSING

Not only is the "BLH" housing streamlined throughout, but its unique fared outlet delivers air to discharge duct with easy, gradual enlargement for best distribution and static conversion.

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**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

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Darling fully revolving double disc parallel seat gate principle features simplicity, ruggedness and smooth, dependable operation. No wedging pressure whatever during gate travel. On closure discs automatically adjust to seat rings throughout life of valve.
This gate valve idea

saves time and money throughout industry!

DARLING gate valves, employing the principle shown in the cutaway above, offer a prolonged bonus in positive closure, freedom from trouble and long life. Such features as uniform wear distribution, elimination of disc-to-seat galling and compensated seating just naturally mean less maintenance, less down time, less expense through the years!

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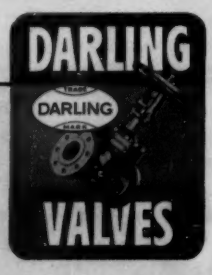
DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.
Manufactured in Canada by
Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.



READER SERVICE . . . TECHNICAL

Automation, Anyone?

AUTOMATION, CYBERNETICS AND SOCIETY. By F. H. George. Philosophical Library, New York. 280 pages. $12.

It's depressing, sometimes, the stuff that finds its way onto printed pages between hard covers.

Take this book. We picked it up thinking, "Ah, here's something for the intelligent layman. Or the pigeon-holed engineer seeking perspective. Or the curious, far-ranging mind." Well, after reading it we're sure it's not for any of these, and can't guess who it is for. We suspect that when the endeavor got under way, no one cared to guess, either. The result is a hodge-podge, a memorable experience in unrewarding reading.

Probably the first mistake was planning a book of such scope. Undoubtedly the author would have had more success had he stuck to one subject, drawing in other material as it appeared pertinent. George is at his best, as in the final chapters on the future of automation, the automatic factory and the future of civilization, when not trying to weave disparate threads into a coherent pattern.

But, out of 280 pages, with all the promising chapter titles, we learned nothing about automation, cybernetics, computers, programming of computers (human and mechanical), psychology, physiology, communication theory and a host of other intriguing topics.

The least we might expect is that the author give us clear exposition. We find, however, such sentences as:

"Also, for somewhat the same reasons that have kept mental entities alive, there has been kept abroad a sort of vitalistic view of behavior, which uses descriptions in terms of operations that cannot be performed in a purely mechanistic way." What does "in terms of"

BOOKSHELF

J. B. BACON

mean? What does the sentence mean?

Most annoying was that the book seemed to make promises but not fulfill them.

For example, in the chapter on cybernetics and psychology, we read on page 141:

"Our next step is to state briefly a general theory of learning as it might appear today."

So, in search of our brief statement, we read our way to the bottom of page 148, where we find:

"The conceptual framework of psychology has been outlined; and we have seen that the most important features were motivation, learning, and perception. There is first the problem of a generalized theory. . . ."

And so it goes.—JBB

More on Heterocyclics

S-TRIAZINES AND DERIVATIVES

By Edward M. Smolin and Lorence Rappoport. Interscience Publishers, Inc., New York. 644 pages. $30. Subscription Price $28.

Reviewed by Philip M. Carabateas, Sterling-Winthrop Research Institute, Rensselaer, N. Y.

Volume 13 of the series "The Chemistry of Heterocyclic Compounds" reviews the chemistry of the 1, 3, 5- or S-triazines, the borazoles, and their derivatives.

The book is concerned chiefly with the chemistry of monomeric compounds, although application of individual compounds is noted, and brief reference is made to the melamine, guanamine, and ammeline resins. Hexamethylene tetramine chemistry is included only when directly related to the S-triazines.

The chemistry of S-triazine itself, the parent member of the series and unknown until 1954,

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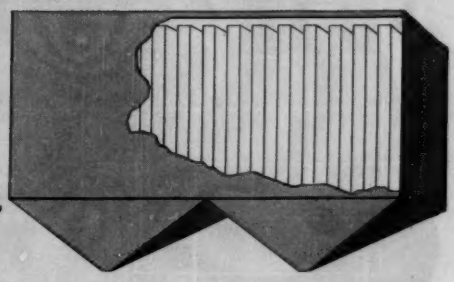

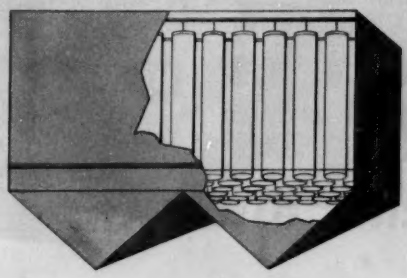

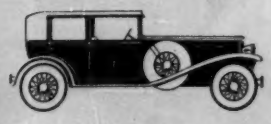

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37% less filtering area per cubic foot of filter.

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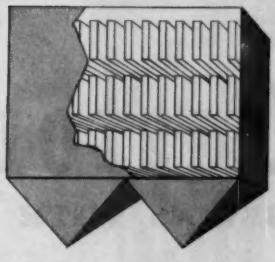

SLY DUST FILTERS PROVIDE 20 TO 40% MORE CLOTH IN A GIVEN SPACE THAN ANY OTHER DUST FILTER.

The new "Roll-Clean" Dynaclone gives: Continuous cleaning, constant suction and complete accessibility in the least possible space.

Space saved with the Dynaclone means: Lower installation costs, lower building costs, simplified piping and ductwork.

Only the Dynaclone furnishes: A single exhaust fan that does the entire job, providing *both* suction for dust collection *and* air for bag cleaning. No auxiliary blowers required.

New "Resist-O-Wear" bags in the Dynaclone offer: 200 to 300% more bag life, easier bag changing, simplicity of construction, and *job-proved* ruggedness.

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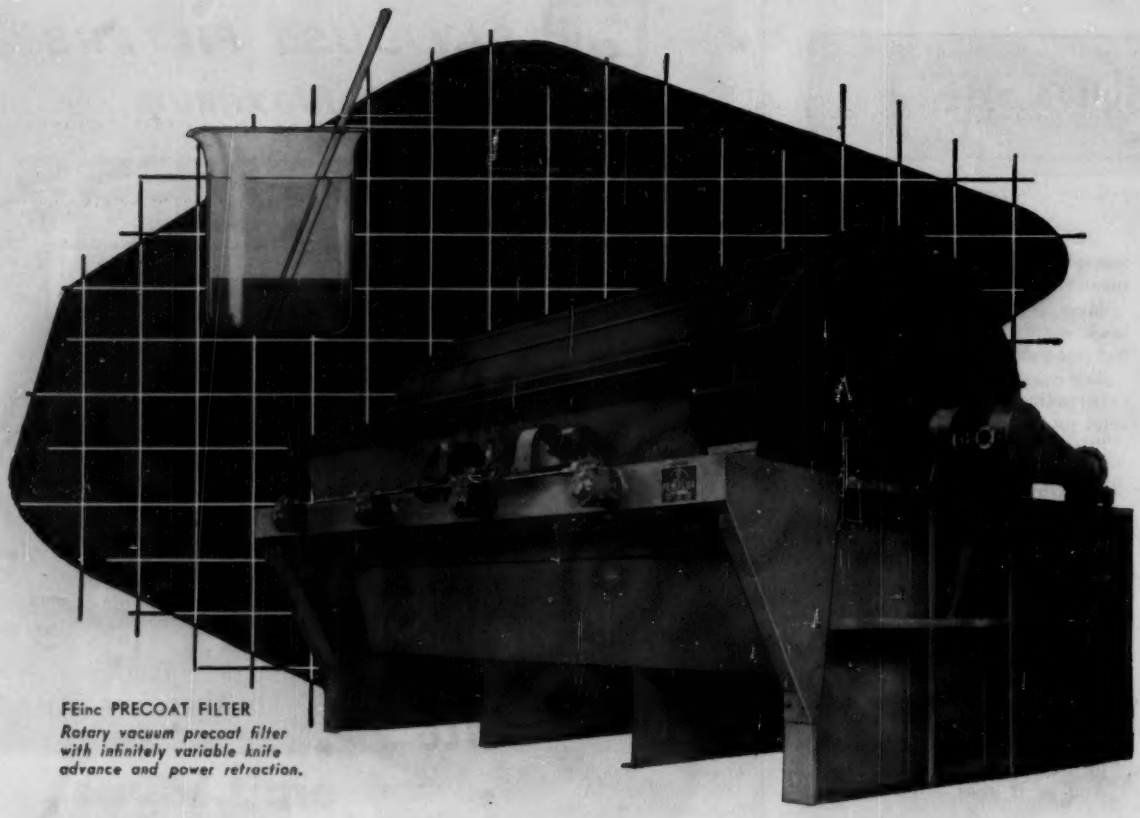

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Rotary vacuum precoat filter with infinitely variable knife advance and power retraction.

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is included in the introduction.

The borazoles are included because of a superficial structural resemblance to the S-triazines and because they are not covered elsewhere in the series.

The authors have comprehensively reviewed the literature through 1953, and some later references are included. Errors and misprints are few.

In summary, this is a comprehensive, authoritative and well written work.

BRIEFLY NOTED

NATION'S ENERGY POSITION. PAST AND PROSPECTIVE DEMANDS, *by Sam. H. Schurr;* THE FUTURE SUPPLY OF ENERGY RESOURCES, *by Bruce C. Netschert. Resources for the Future,* 1145 *Nineteenth St., N. W., Washington* 6, *D. C.* 50¢ *each, single copies free on request.* Statements presented before the Subcommittee on Automation and Energy Resources of the Joint Economic Committee. Reprinted from record of the hearings, Energy Resources and Technology, Government Printing Office, Washington. Limited supply.

MORE NEW BOOKS

NUCLEAR RADIATION ENGINEERING —AN INTRODUCTION. By F. W. Hutchinson. Ronald Press. $6.

AN OUTLINE OF UNITED STATES PATENT LAW. By Richard E. Brink, Donald C. Gipple and Harold Hughesdon. Interscience. $7.50.

THE CHEMICAL WARFARE SERVICE: ORGANIZING FOR WAR. By Leo P. Brophy and George J. B. Fisher. Superintendent of Documents, Government Printing Office. $4.

REACTIVE METALS. Edited by W. R. Clough. (Metallurgical Society Conferences, Vol. 2.) Interscience. $15.

NON-BENZENOID AROMATIC COMPOUNDS. Edited by David Ginsburg. Interscience. $18.

LIPIDE CHEMISTRY. By Donald J. Hanahan. Wiley. $7.50.

TELEMETERING SYSTEMS. By Perry A. Borden and W. J. Mayo-Wells. Reinhold. $8.50.

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"In half the time needed by our old filter press, we can run a batch of gelatin in the thin liquor stage through our new NIAGARA VERTICAL FILTER," says Edward Bohn Jr., assistant plant superintendent for one of the largest U. S. gelatin producers.

Remarkable reductions in down time and labor costs also are reported by Kind and Knox with its new NIAGARA FILTER. "Resetting the NIAGARA for a new run takes one-fourth the time and one man can handle the procedure without a helper," Bohn says. "Our regular filter press requires two men working two hours to change 50 filter cloths. With NIAGARA, hot water under pressure completely removes the residue in minutes, and the unit does not have to be opened. Also, there are no filter cloths to clean or replace in our NIAGARA FILTER."

The plant operates 24 hours a day, 7 days a week, and to date there has been no operational trouble with the NIAGARA FILTER. This compact filter has a base measurement of only 52" x 102", so there is a big savings in floor space.

For details on how custom engineered NIAGARA FILTERS can help with your processing problems, write for bulletin NC-457, or see the NIAGARA section in Chemical Engineering Catalog.

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DEPT CEN—360

EAST MOLINE, ILLINOIS

LETTERS:

JUST BETWEEN US...

Dear Readers:

When you get this issue, Martin D. Robbins, formerly of our New York staff, will be taking up his new chores as *Chemical Engineering's* Western Editor.

His new home base is, of course, San Francisco (68 Post St.). But at this moment Marty is probably beating the bushes for important news stories and feature articles in Los Angeles. And soon thereafter we suspect he'll be heading for Seattle or Denver or Salt Lake City, or maybe Juneau or Honolulu. For that's the nature of this job and the nature of the man who now fills it—to cover in depth and breadth the thriving chemical process industries of the thirteen states of the U. S.'s Golden West.

Marty's ability to handle this challenging assignment is rooted firmly in a solid background of editorial and industrial experience. A member of our New York staff for the past three years, he has been directly responsible for some of the most significant editorial pages to appear in our magazine. For example, Marty was the creator, two years ago, of *CE's* popular Operations & Maintenance de-

PRO & CON

C. H. CHILTON

partment. Too, he was responsible for the articles on high-temperature materials which won for *CE* the coveted *Industrial Marketing* Award of Merit for the best article series of 1958.

Marty received a bachelor's degree in chemistry from Tufts in 1954, a master's degree in ceramics and materials engineering from MIT in 1956. He then worked for Du Pont in Perth Amboy, N. J., as a process engineer until he joined *CE*.

This rehearsal of Marty's professional qualifications fails to show what a unique and winning personality we've sent to cover the West's booming CPI. Marty Robbins has been the shining light of the staff here in New York, what with his incomparable adventures, unmatched elan and wit and endlessly fascinating conversation. He has been, to our great amusement and edification, a sports-car rallyist of unusual map-reading abilities, an habitue of most of Manhattan's unrecorded locales, a devotee of pre-Columbian ceramic art and an intimate of back-stage Broadway.

We in New York have sent Marty west with not a little reluctance. But our loss of this engineer, editor and friend is the West's gain. We invite our western readers to get to know Marty Robbins.

T. PETER FORBATH
Associate Editor
Chemical Engineering

P.S.—The many friends of Emil Mikity, who served as our Western Editor until last month, will be pleased to learn of his advancement to the post of assistant managing editor of our sister publication, *Chemical Week*.—TPF

Engineers in Politics

Sir:

Your article, "Engineers Enter the Political Arena" (Jan. 25, pp. 115-118), gives me the impression that engineers should act as part-time, unpaid lobbyists—as

PHOTO COURTESY OF HOFFMANN-LA ROCHE, INC., NUTLEY, N. J.

Constant quality control and top efficiency with BATCH-O-MATIC®

This completely *automated* BATCH-O-MATIC reduces exposure time to maintain product stability in centrifugal extractor operations. These machines can be constructed of stainless steel, "Hastelloy," titanium or other alloys. Corrosion-resistant coatings may be specified.

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Please send illustrated details on the BATCH-O-MATIC. I'd also like information on TOLHURST manual models ☐.

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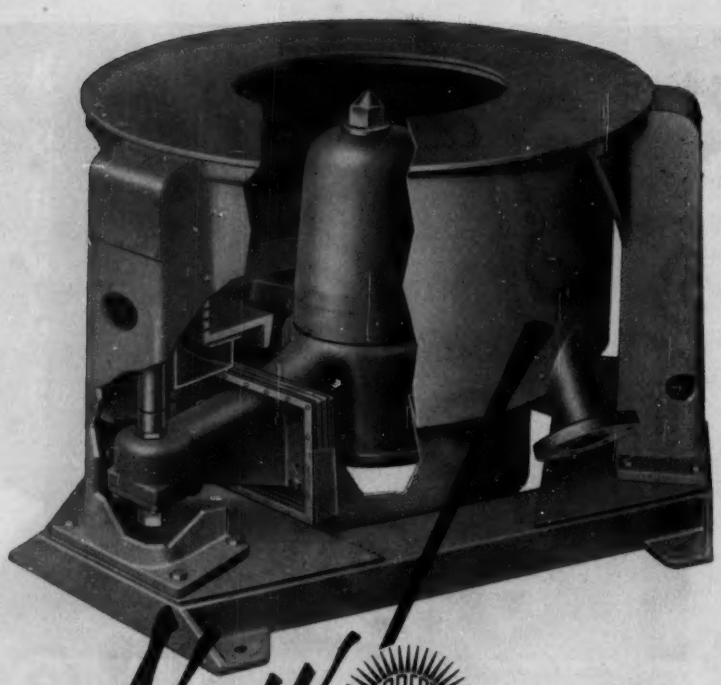

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Features . . . Link Suspension! No metal to metal moving parts. No lubrication. Soft lateral movement. No vertical movement. Effective damping. This suspension isolates dynamic parts from curb and foundation and reduces vibration to an astonishing low.

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long as they support lower corporation taxes and other "approved" objectives selected by bodies such as the Texas Manufacturers' Assn. and "objective political education groups."

I wonder what Mr. Tom A. Wilker of Union Carbide's Texas City plant would say if one of his staff actively espoused desegregation.

JOHN E. ULLMANN
Stevens Institute of Technology
Hoboken, N. J.

Pro: McCabe-Thiele

Sir:

Mr. Wing's idea (Oct. 19, pp. 185-188) of putting a scale of temperature along the y axis in the McCabe-Thiele diagram is new, so far as I know, and may sometimes be useful. But I do not think the temperature scale need displace the vapor-composition scale. The two scales can be put alongside the same line; or a fussy person could put temperatures along the right-hand side of the diagram.

As for the misspelling of my name throughout the article, I have long since become resigned to having it both misspelled and mispronounced.

E. W. THIELE
Standard Oil Co.
Whiting, Ind.

Pro: Licensing

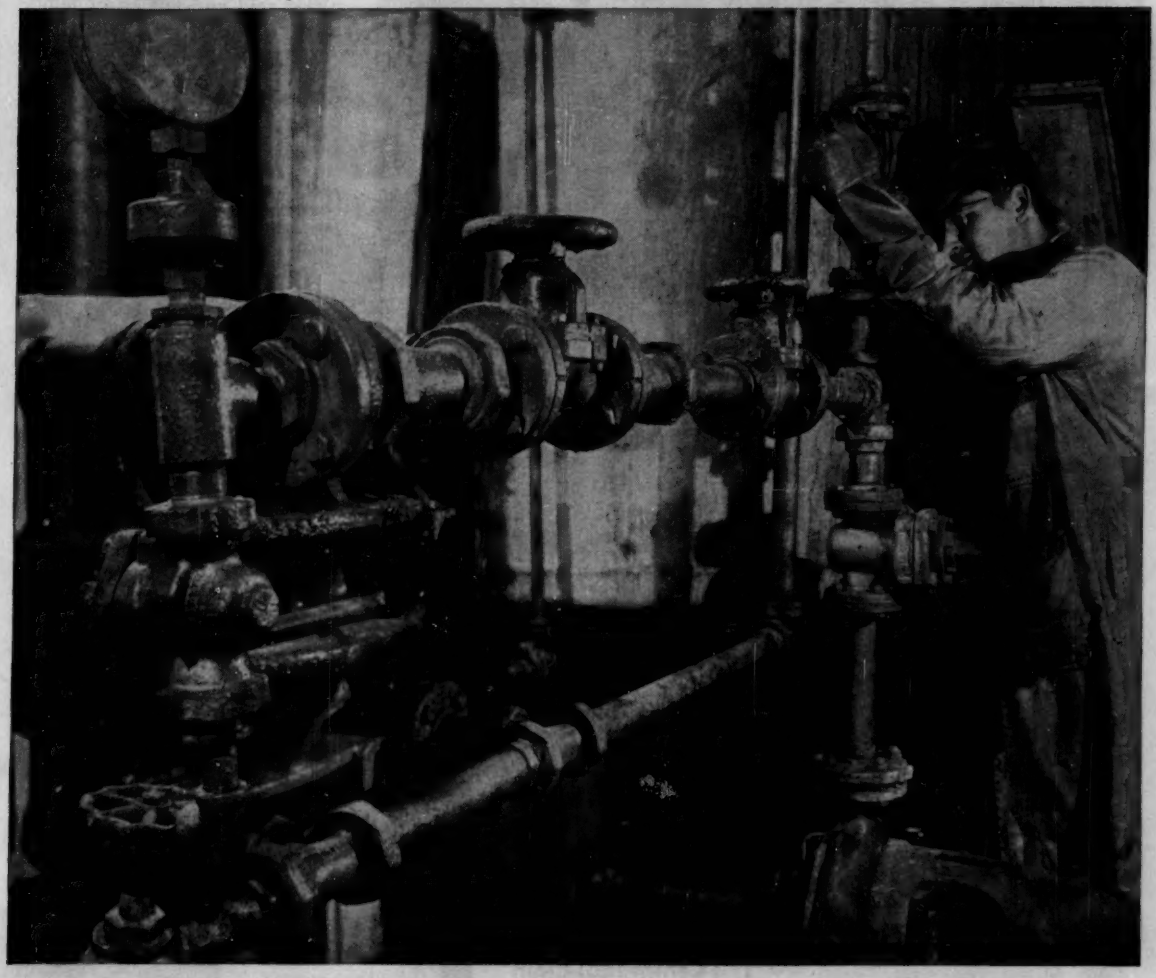
Sir:

I think you have done the engineering profession a great disservice by publishing Mr. Gray's article, "Why Engineering License Laws?" (July 13, pp. 166-170).

The article is rather superficial from a legal point of view. In fact, I cannot see what its point is, except that a person should be permitted to practice engineering without registration when the public safety is not involved. I would be very much interested to know what these circumstances are.

Can anyone who is familiar with Mendeleef's Tables and valences practice as a chemical engineer? Can he mix glycerine, sulfuric acid and concentrated

DOW | **SARAN LINED PIPE**



After eight years carrying lithium chloride brine . . . No Corrosion in Saran Lined Pipe

When pipe must carry extremely corrosive lithium chloride brine . . . when floor-level installation freely exposes it to danger of accidental damage from trucks and tools . . . doubly protective Saran Lined Pipe can mean dependable, low-maintenance operation for many years.

Lithium Corporation of America's Minneapolis, Minnesota, plant produces pure lithium metal as well as various lithium salts. In the production of lithium chloride, Saran Lined Pipe is used to carry LiCl brine to drying equipment for the removal of water. This brine is extremely corrosive and will quickly eat through steel pipe should a crack develop in the lining. Other Saran Lined Pipe carries suspensions of lithium fluoride and hydrofluoric acid, a combination which will attack and destroy even glass. Because of its strength and extreme corrosion resistance, there's never been a failure in the Saran Lined Pipe.

Saran Lined Pipe at this plant is installed close to floor level in some working areas, constantly exposed to the danger of accidental damage from trucks and tools. Lithium's engineers stated, "Saran Lined Pipe provides protection from outside damage and from corrosion by the solutions carried. In eight years of pumping LiCl brine through Saran Lined Pipe at 30 to 50 psi, there's never been a breakdown, and very little maintenance was required."

Saran Lined Pipe, fittings, valves and pumps are available for systems operating from vacuum to 300 psi, from below zero to 200° F. They can be cut, fitted and modified easily in the field, without special equipment. For more information, write Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale, Michigan, Dept. 1780-AK3-7

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nitric acid and not affect public safety?

EDGAR L. MORRIS
Counselor at Law
Columbia, S. C.

► *The best answer to Mr. Morris's have - you - stopped - beating - your-wife type of question is the simple fact that the majority of practicing chemical engineers today are not licensed; ergo, their work does not involve public safety.*—ED.

Pro: Industrial Engineers

Sir:

In your Oct. 19 issue, the pictorial diagram preceding the article on "personnel engineering" (p. 210) indicated various branches of engineering. It failed to show one of the growing important branches—industrial engineering.

Your publication is edited for "profit-minded engineers" in the chemical process industries. We have found that industrial engineering is an important part of the team in our efforts.

W. R. ATCHISON
Olin Mathieson Chemical Corp.
Covington, Ind.

► *Naturally we couldn't possibly include all branches of engineering in our illustration, so we stuck to the branches represented by the five so-called "founder" societies—ASCE, AIME, ASME, AIEE and AIChE.* —ED.

DMS, DMSO Patents

Sir:

Your *Chementator* story (Nov. 2, p. 17) on our dimethyl sulfoxide operations contains an error as to the inventors and owners of the process patent.

The DMSO process we are using was invented by Wetterholm and Fossan and is owned by the Swedish firm, Nitroglycerin Aktiebolaget. Hagglund and Enkvist were the inventors of the dimethyl sulfide process we are using; this patent is owned by the Swedish Cellulose Assn. We have exclusive U. S. and Canadian rights to both processes.

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Heavy-duty Badger water meters

maintain high accuracy ... low pressure loss

These precision-built Badger meters are designed for heavy industrial service.

Disc meters are available from ⅝" to 2"; turbine meters, from 2" to 12" inclusive. 2" stainless steel oscillating piston models also available. All handle flows to 150°F.

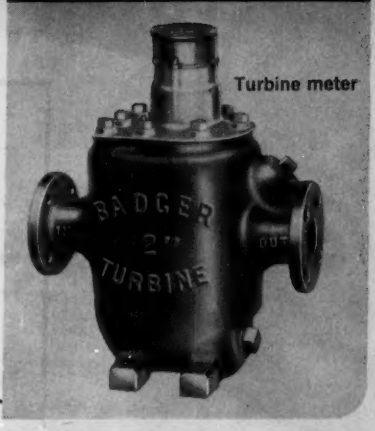
Typical applications: Batching meters for chemical and fertilizer plants; interdepartmental metering; regulation of water treatment. Electric alarm, electric contacting and remote reading registers are offered as accessories.

Write for descriptive literature

Badger Meter Mfg. Co.

Industrial Products Div., Milwaukee 23, Wis.

Disc meter



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with ROCKWELL "D-D" VALVES

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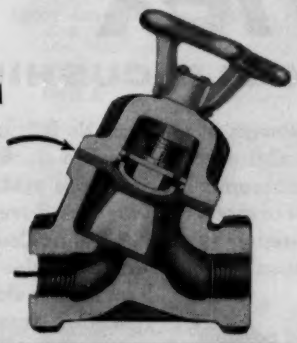

DIAPHRAGM for Positive Sealing

DISC for Positive Closure

OPERATION Disc absorbs action of fluid flow and pressure, and cuts off fluid on closure. Diaphragm merely seals mechanism from valve body. Failure of diaphragm does not prevent closing the valve. Hence—longer diaphragm life—less maintenance. Oversized ports for higher capacity.

CONSTRUCTION Valve bodies of cast iron, stainless steel, or lined with rubber, Neoprene, Penton, other plastics or glass. Diaphragm discs of rubber or Neoprene. Flanged — ½" to 6" sizes; screwed or union ends — ½" to 2" sizes. Write for Bulletin 800C.

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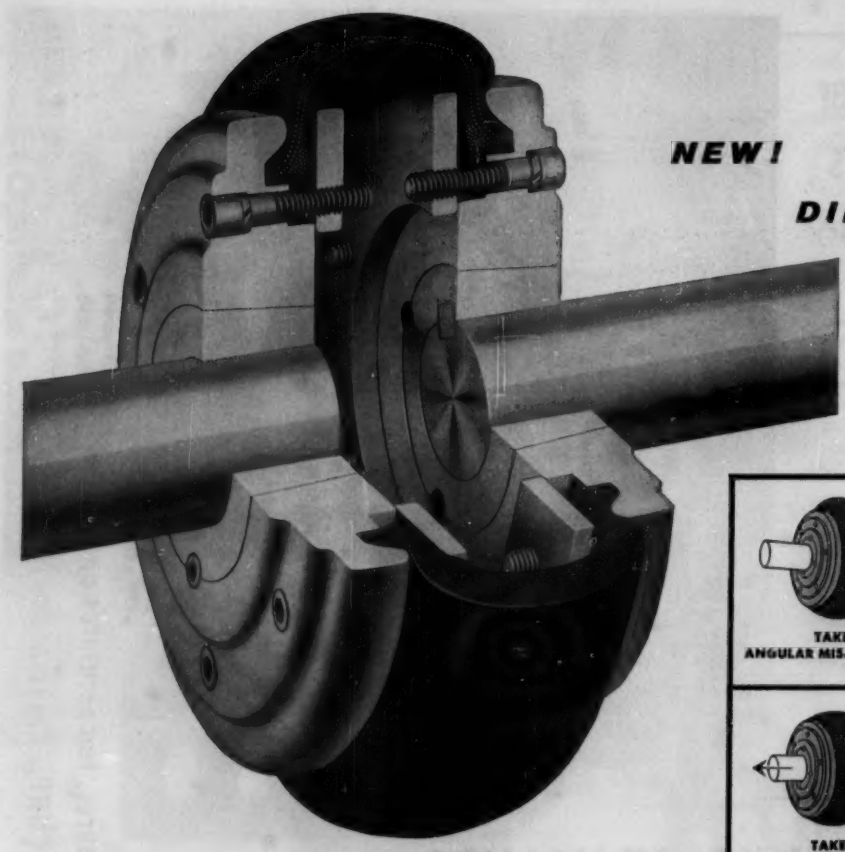
Technical information on request — write DURAMETALLIC CORP., Kalamazoo, Michigan



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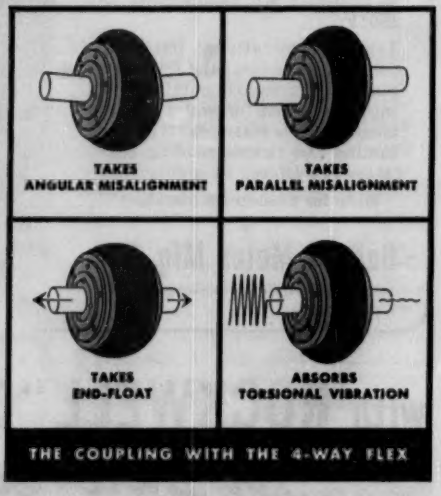

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Para-flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 2000 hp at 1080 rpm. Call your distributor for a coupling to *make your own test.* You'll witness something revolutionary!

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TECHNICAL LITERATURE

E. M. FLYNN

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Chemicals

Activated Charcoal.....acts as a molecular sponge, purifies air, gase, and liquids. Recovers solvents and removes odors and impurities. Bulletin J-102.
L219 *Barneby Cheney

Activated Manganese Dioxide.....Data sheet gives information on reagent used for oxidation of alylic and benzylic alcohols.
203A
Beacon Chemical Industries, Inc.

Aerosol Propellents.....Technical article gives five methods of blending. Discusses proportioning pumps, displacement meter and weigh tank. Tables, drawing included.
203B Union Carbide Chemicals Co.

Agricultural Chemical.....Pamphlet lists chemical analyses and physical properties of sorptic attapulgus clay used as carrier and diluent for granular insecticides, etc.
203C Minerals & Chemicals Corp.

Alloys.....Samples of alloys are available for testing under your own process conditions. Also a copy of the 104-page corrosion book is offered.
165 *Haynes Stellite Co.

Catalysts.....Facilities for producing carload quantities of performed catalysts to fit special process requirements. Booklet, "Harshaw Catalysts" is offered.
81 *The Harshaw Chemical Co.

Chemical.....Anti-Foam comes to you in concentrated form (30% silicones) for easier handling & storage. A free sample available.
177
*General Electric, Silicone Products

Chemical Cleaners.....18 p. bulletin No. 102 discusses power plant, stainless steel, aluminum metal & alloy and general chemical cleaning. Also covers bottle washing.
203D Chas. Pfizer

Chemicals.....Booklet "Mutual Chromium Chemicals" and a list of manufacturers of corrosion inhibiting compounds is now available.
77
*Allied Chem., Solvay Profess Div.

Chemicals.....36 p. catalog & directory reviews company's products in basic chemicals, monomers, polymers, resins, adhesives, coatings, plastic products.
203E Borden Chemical Co.

Chemicals.....Information on Acids, Binding Resins, Elastomers, Plastics, Oils, Waxes and Greases, Dispersions, Fluorochemicals, Surfactants and Inert Liquids.
10-11
*Minnesota Mining & Mfg. Co.

Chemicals.....The 1959 Physical Properties of Synthetic Organic Chemicals . . . a comprehensive description of the properties & applications of chemicals.
151b *Union Carbide Chem. Co.

Diatomite.....Every grade of Celite offers constant uniformity. Assistance with specific filtration or mineral filler problems is available on request.
153 *Johns-Manville

Dielectric Material.....2 p. data sheet discusses electrical, chemical, physical properties of reinforced theromsetting plastic insulating material. Covers end uses.
203F Rex Corp.

Dispersants.....The chemical & physical characteristics of Marasperses plus other technical data is covered in Bulletin No. 125.
203G
Marathon Div. of American Can Co.

Epoxy Laminates.....Two 1 p. bulletins, Nos. 607AA & 606 describe two improved non-irritant epoxy laminating systems now being made commercially available.
203H Marblette Corp.

Esters.....Specifications, physical properties and solubility data of fatty acid esters for textiles, paints, lubricants, cleaning compounds given in 40-page catalog.
203I Kessler Chemical Co., Inc.

*From advertisement, this issue

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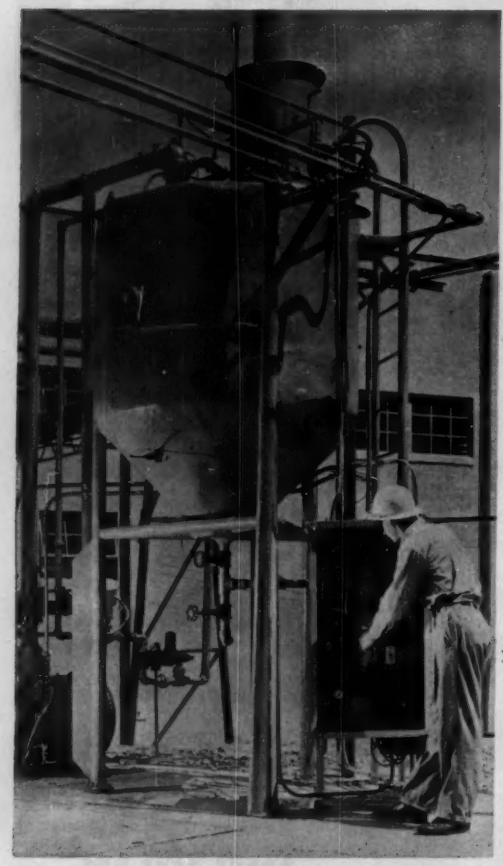

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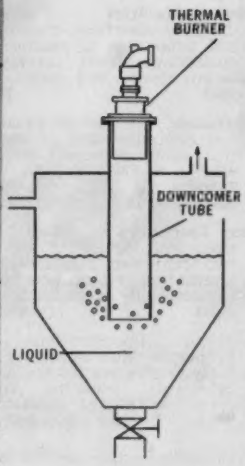

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LITERATURE . . .

Fluorine-Containing Acetones..... Data sheet and technical report on the properties and reactions of fluorine-containing acetones is available on request.
57 *Allied Chem., Gen. Chem. Div.

Fluorocarbons.....4 p. bulletin, "Blowing Foams with Isotron," discusses recent developments in urethane foam making technique by blowing with fluorocarbons.
204A Pennsalt Chemicals Corp.

Fused Quartz.....Vitresoil offers absolute chemical purity, extreme heat resistance and thermal shock resistance. Catalog.
R216 *Thermal American Fused Quartz Co.

Holmium.....Properties of relatively corrosion resistant rare earth metal given in data sheet. Includes melting-boiling points, structure, atomic radius and magnetic moment.
204B Nuclear Corp. of America

Hydrogen Peroxide.....63 p. bulletin convers properties, handling, dilution and storage. Contains numerous charts, graphs and tables on physical properties.
204C Allied Chemical

Hydroxyethyl Cellulose.....Information on Cellosize HEC properties, where and how to use it, plus other valuable data can be obtained on request.
151a *Union Carbide Chemicals Co.

Lubricant.....3 p. report TDR N-108 covers company's synthetic lube ESL 3A, ester-based fluid for use in gas turbine aircraft. Covers Corrosion, oxidation stability.
204D Eastman Chemical Products

Olefins.....4-page guide tabulates physical properties of 1, 3-butadiene, ethane, methane, propylene, toluene, calcium hydroxide etc. In-
204E Union Carbide Olefins Co.

Organic Chemicals.....52-page companion catalog booklet gives classification by functional groups of 3700 organic chemicals. Cross references and catalog guide listings included.
204F Eastman Kodak Co.

Phosphate-based Plasticizers.....Celluflex FR-2 is a prime fire-retardant additive for urethane foams, phenolics, polyester & other plastics. Complete data on request.
73 *Celanese Corp. of America

Plastics.....16 p. booklet outlines properties, applications, availabilities of company's nylon, Teflon, and other new industrial plastics. Covers sintered parts.
204G Polymer Corp.

Plastics.....Prices and information on grades, sizes and tolerances of plastic sheet, rod, tubing, etc. given in catalog. Includes tables of properties of widely used plastics.
204H Almac Plastics, Inc.

Polypropylene.....4-page brochure describes properties and applications. Includes heat and chemical resistance, electrical properties, finishes, and films and filaments.
204I Catalin Corp. of America

Polyethylene.....Heat-sealing characteristics of polyethylene films given in booklet. Details on sealing of unsupported film or bags and influences of resin density included.
204J U. S. Industrial Chemicals Co.

*From advertisement, this issue

PVP/VA Copolymers.....Bulletin describes stability factors, viscosity ratings, compatibility and physiological data of material with adhesive and film-forming properties.
205A General Aniline & Film Corp.

Silicones.....8 p. 1960 guide to company's complete line of silicone products lists major uses and benefits. Features antifoam & release agents, lubes, paint.
205B General Electric Co.

Sodium Hydride.....The new 20-page brochure, "Sodium Hydride Dispersed In Oil," a manual covering properties, reactions, handling & safety is available.
79 *Metal Hydrides Inc.

Solvents.....Alcohols, Esters and Ketones for use in the surface coatings industry. Complete technical facilities are at your service. Data is available.
69 *Enjay Company, Inc.

Styrene Polymer.....Technical service bulletin gives data and information on techniques used to evaluate product. Performance curves and pertinent property values.
205C Monsanto Chemical Co.

Succinic Anhydride.....The 40-pg. tech. Bul. 1-11 contains complete physical properties and all important reactions.
33-34
*Allied Chem., Nat'l. Aniline Div.

Surfactants.....8-page bulletin gives information on physical properties and end uses. Includes data on two carboxylic type surfactants with corrosion inhibitor properties.
205D Geigy Industrial Chemicals

Surfantants.....Technical grades and descriptions of series of dioctyl, dihexyl and di-isobtuyl sulfosuccinates used for compounding of pesticides and fertilizers given.
205E Mona Industries, Inc.

Zirconium.....Fact file contains technical data, applications and available forms of metal used as a prominent construction material in atomic reactors.
205F Zirconium Association

Construction Materials

Alloy.....Detailed information on the corrosion resistance of Ni-o-nel alloy, its physical constants, tensile properties, & fabrication available in a new booklet.
205G The International Nickel Co.

Coating.....Kanigen applies a hard, corrosion-resistant nickel alloy coating without the use of electricity. Further information on request.
28 *Gen. American Transp. Corp.

Castings, Stainless.....A 28-page booklet of valuable & complete data on stainless castings. Included analyses, properties, technical data on handling & heat treatment.
97 *Allegheny Ludlum Steel Corp.

Filteraid.....A new illustrated brochure covering the properties and characteristics of Nerofil, a new type of filteraid made from a special form of carbon is offered.
205H Great Lakes Carbon Co.

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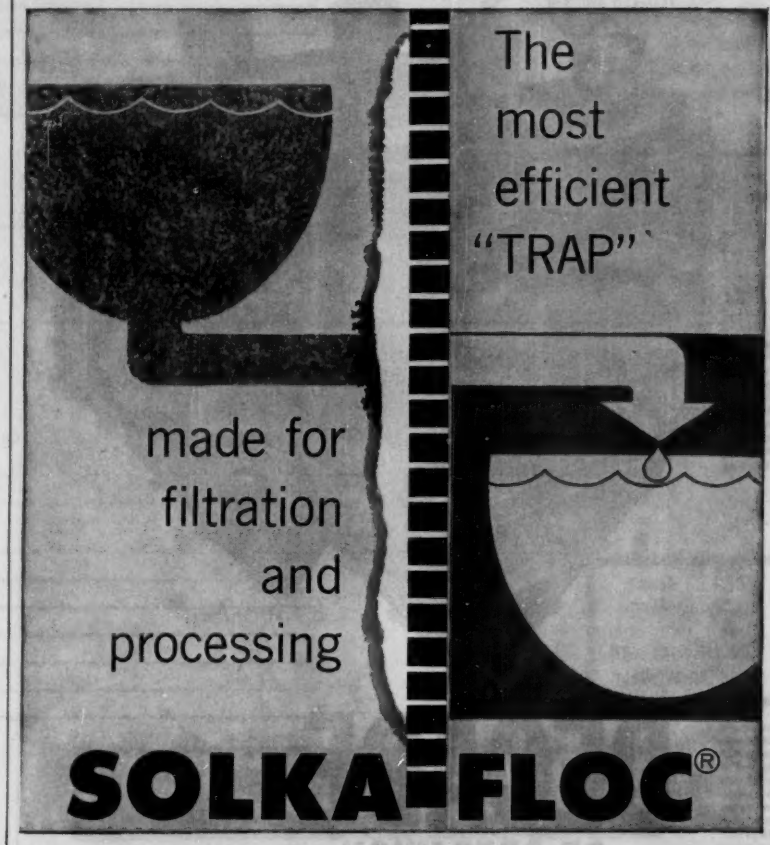

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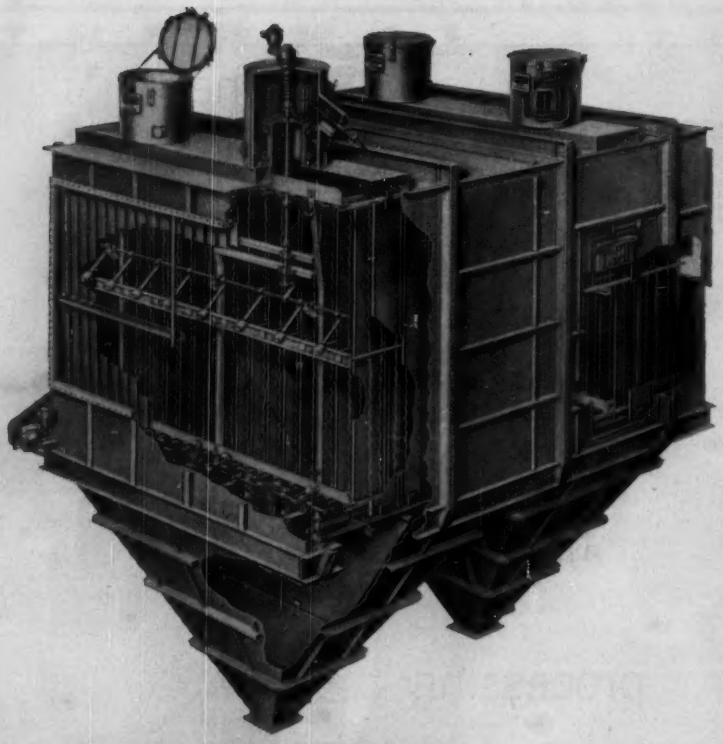

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LITERATURE . . .

Filter Cloth.....all weaves, all metals, all weights. Available in rolls or cut to size. Most efficient woven wire filter cloth. More information in Bulletin F-C.
200 *Newark Wire Cloth Company

Insulation.....Calsilite is an ideal one-layer insulation for soaking heat up to 1250 F. It is lightweight, easy to cut, mitre. Insoluble in water. Details.
L218 *The Ruberoid Co.

Lining.....PLIOWELD super-tough lining defies the destructive action of a wide range of abrasives and corrosives. Information.
15 *Goodyear, Industrial Products Division

Packing.....Homogeneous Compressed Asbestos Sheet Packing is available in 8 different gauges. Full information about gasket material in CE 30.
179 *Durabla Mfg. Co.

Packing.....Intalox Saddle Packing is covered in Bulletin S-29 which gives full information. Packed with technical data every chemical engineer can use.
50 *U. S. Stoneware

Packings.....Chempro Style 300 "Cup & Cone" and Style 305 "Wedge" packing ring sets are two new resilient packagings. Bulletin CP-552.
L220
*Chemical & Power Products, Inc.

Plastics.....New booklet gives product specifications, uses & application techniques for flat & corrugated fiberglas reinforced plastics in plant maintenance.
206A American Polyglass Corp.

Protective Coatings.....Plasite cold set coatings are formulated from high resistant resin combinations to achieve highest chem. resistance possible. Bulletins.
L221 *Wisconsin Protective Coating

Rubber & Plastic Tank Linings..... for alkalies, acids, bleaches, salts. Faultless seams, indestructible bond, shock and age-resistant. Bul. CE-53.
189c *American Hard Rubber Co.

Stainless-Clad Steel.....Bulletin on clad steels is available. Application Research can help you find the right steel plate for the job. Available on request.
30 *Lukens Steel Co.

Stainless Steel Plates.....Further information on world's largest stainless steel plates ready for processing is now available on request. Send for your copy.
93 *G. O. Carlson, Inc.

Electrical & Mechanical

Conveyor Pulleys.....Technical data available on these taper-lock steel conveyor pulleys. Maximum strength with minimum amount of weight.
203b *Dodge Manufacturing Corp.

Insulating Materials.....12-page booklet describes in text, tables and illustrations characteristics and applications of insulating materials for electrical equipment.
206B General Electric Co.

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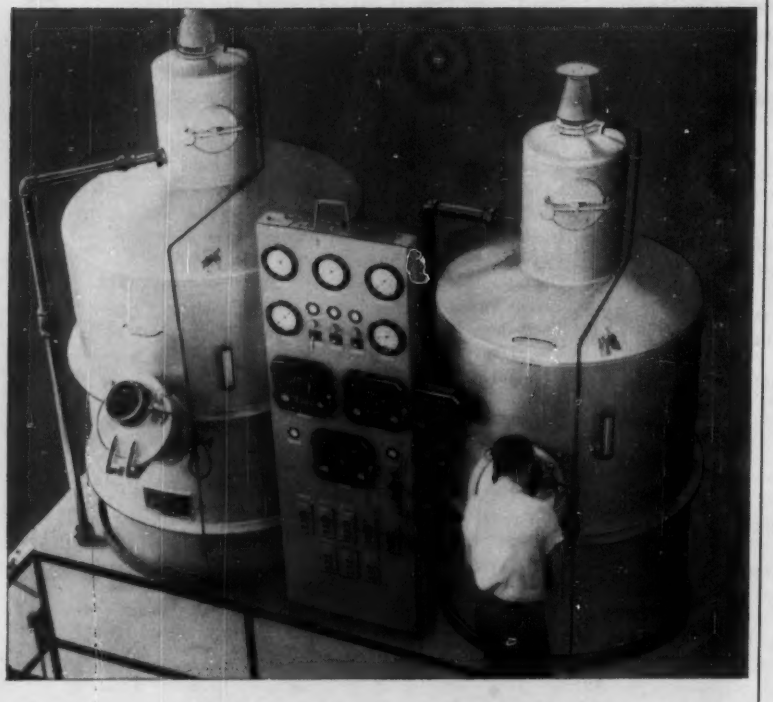

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LITERATURE . . .

Magnetic Drives.....Leaflet describes new line of variable speed drives designed for pump application. Drives are air-cooled and speed variation is between 0-1740 rpm.
210A Electric Machinery Mfg. Co.

Mechanical Seal.....The Dura Seal provides mechanical sealing for the widest range of pressures, temperatures & speeds. Technical information on request.
R201 *Durametallic Corp.

Motors.....Many types of motors for many uses in many industries. Also automatic controls, geared or belted drives, etc. Color-illustrated brochure offered.
233 *U. S. Electrical Motors Inc.

Rolling Bearings.....Further information available on these rolling bearings. Information includes ratings as well as other pertinent data sent on your request.
203a *Dodge Manufacturing Corp.

Rupture Discs.....designed to rupture at any specified pressure from 3 to 100,000 lbs. per square inch. Sizes range from ⅜" to 36" diameter & in special sizes.
173 *Black, Sivalls & Bryson, Inc.

Speed Variators.....provide both increase & decrease of output speed on a range up to 9:1 from a constant speed power source. Bul. K-25 *The Cleveland Worm & Gear Co.

Swivel Joints.....US type swivel joints are designed exclusively for the chemical industry. Joint can be welded into the line. Catalog now available.
63 *Continental-Emsco Co.

Take-Ups.....A complete range available of stock models, sizes. Information on roller, ball, babbitted available on request. Also other pertinent details.
203c *Dodge Manufacturing Corp.

Thermocouple Wires.....tremendous variety available. Dependable quality control assured. See full line by requesting Wire Bulletin 32WS-4 which is now available.
TL213 *Thermo Electric Co., Inc.

Turbines.....Complete details on these Vertical Steam turbines contained in Catalog 200. Turbines in sizes 1 hp to 250 hp. Feature brake rim for added safety.
111 *Coppus Engineering Corp.

Handling & Packaging

Bagging Scale.....The E-50 is accurate within 1 ounce at speeds of ten or more 50 lb. bags per minute. Full details on the E-50 & other bagging scales offered.
184 *Richardson Scale Co.

Compression Sealer.....Automatic machines for gluing-sealing of paperboard shipping cases. 8-page brochure gives dimensions and description of operating sequence.
210B J. L. Ferguson Co.

Conveyors, Oscillating.....Flexmount for light-duty, Coilmount for medium duty, and Torqmount for heavy-duty service. New Book 2744 contains complete data.
17 *Link-Belt Co.

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Mechanical Seals.....4-page design data folder contains two nomograms to facilitate determination of frictional heat and power absorption.
211A Sealol Corp.

Metal-Mesh Belts.....combine movement with processing to give you greater production & consistently high quality without costly manual handling. 130-Pg. Manual.
89 *The Cambridge Wire Cloth Co.

Payloader.....Data on the new H-30 with four-wheel drive plus data on other "Payloader" models sizes from 2,000 to 12,000 lb. operating capacity.
35 *The Frank G. Hough Co.

Heating & Cooling

Dryer, Desiccant.....The Heat-Les dryer offers dewpoints to 200 F. No heaters to replace or power & no increase in air temperature. Complete details.
176 *Trinity Equipment Corp.

Dryers.....Lectrodryers dry to dewpoints below 110 F., in volumes of a few cubic feet or thousands per hour. Operation can be fully automatic or manually controlled.
172 *Pittsburgh Lectrodryer Div.

Dryers.....Drying Equipment for the Food, Chemical and Process Industries . . . Conveyor Dryers, Spray Dryers, Tray Dryers, Truck Dryers. Bulletin #448.
101 *Proctor & Schwartz Inc.

Evaporators.....Used for all chemicals —acids, salts, pharmaceuticals, recovery of industrial waste. Right evaporator can be job-tailored for your product. Cat. 372.
210 *Blaw-Knox

Grate Coolers.....Bulletin describes horizontal and inclined grate coolers. Illustrations and schematic drawings are included. Also gives information on clinker breakers.
211B Fuller Co.

Heat Exchangers.....The "Polybloc" impervious graphite heat exchanger is covered in a new booklet. Principles of operation, applications and complete design data included.
211C The Carbone Corp.

Heat Transfer.....The new Multi-Zone Platecoil introduces a new principle of coil design. Solves tough tank & process heating problems. Data in Bul. P61.
75 *Tranter Mfg. Co.

Heat Transfer Systems.....Research & testing facilities help bring the latest scientific advances in pyroprocessing in each system. Bulletin 25C6177.
65 *Allis-Chalmers

Kilns, Rotary.....have all welded steel shells, feed & discharge end seals, heat recuperating chain systems for wet process kilns, improved kiln feeders, etc. Bul. 1115.
14 *Traylor Engr. & Mfg. Co.

Steam Traps.....The Yarway No. 30 gives you closer control . . . discharges condensate at full capacity, closes immediately on steam. Quiet operation. Details on request.
43 *Yarnall-Waring Co.

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Hamer Line Blind Valves

It has long been recognized that convention type valves do develop leaks. And contamination of product when it occurs costs dearly in time and money. Preventing this is where Hamer Line Blinds excel. Handwheel or bar operated, Hamer Line Blind Valves squeeze dead tight against the center spectacle plate forming an impassable line shut-off that's both permanent and absolute. Yet Hamer Line Blinds are fast, safe, simple to operate. One man can open or blind a line in one minute. Investigate Hamer Line Blinds. Let a Hamer representative show you how these remarkable valves can actually pay for themselves.

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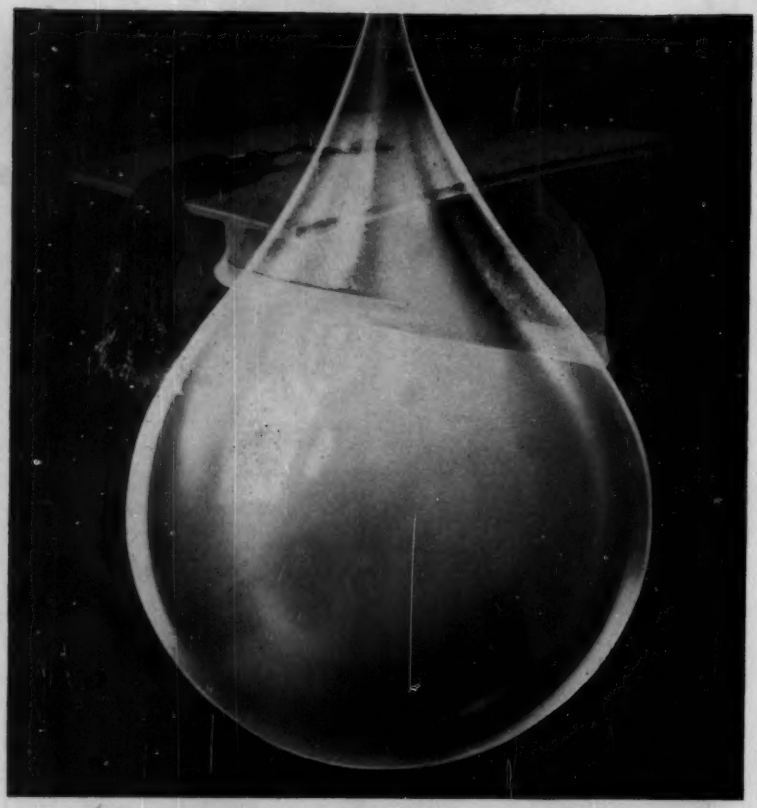

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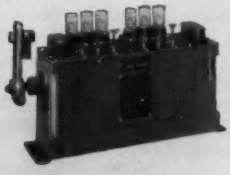

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LITERATURE . . .

Steam Traps.....The 44-page steam trap book discusses trap selection, installation and maintenance. Covers its excellent air handling characteristics.
29 *Armstrong Machine Works

Temperature Controls.....A handy, condensed catalog of the complete line of temperature controls & allied equipment for industrial heating & refrigeration.
40 *The Partlow Corp.

Thermo-Panels.....for the utmost in drum warming or cooling modern chemicals. Complete data & costs on thermo-panel drum warmer or cooler in Form DW-6-1.
T231 *Dean Products Inc.

Thermal Submerged Combustion..... high efficiency and compact size—at lower initial cost. May be fired by gas distillate oil. Bulletin 115.
204
*Thermal Research & Engineering Corp.

Vacuum Induction Melting.....New 36 page brochure describes process and discusses present and future applications of superalloys. Photos illustrate production techniques.
212A Kelsey-Hayes Co., Metals Div.

Instruments & Controls

Analog Computers.....4-page booklet describes techniques and applications. Two problems are investigated to show scaling and programming.
212B Donner Scientific Co.

Analyzer-Recorder.....gives you a continuous recording of both oxygen and combustibles on the same chart for quick, simple comparison. Information on request.
96 *Bailey Meter Co.

Circuit Breaker.....New 60-page catalog provides information on molded case and individually enclosed low-voltage power circuit breakers and other products.
212C I-T-E Circuit Breaker Co.

Comparators.....for fast, easy tests for pH, Chlorine, Phosphate. Handbook gives theory & application of pH control & describes the complete line.
R220 *W. A. Taylor & Co.

Control Panels.....Selection of correct control panel for a variety of automatic materials handling systems is the subject of new bulletin. Four basic types are described.
212D Fuller Co.

Controller.....The 53P incorporates the principle of regenerative feedback to give you improved linearity & increased gain. Details on 53P controller in Catalog 53P-4000.
42 *Fischer & Porter Co.

Controls.....Explosion-proof Electronic Level-Trol features external adjustment for proportional band & liquid level height. Bulletin F-85 gives complete details.
88 *Fisher Governor Co.

Diaphragm Pressure Regulators..... The new 1065 series is offered in 4 diaphragm sizes, with 9 different ranges from 0.5 to 150 psig. Complete specifications in Bul. EC-125.
175 *Robertshaw-Fulton Controls Co.

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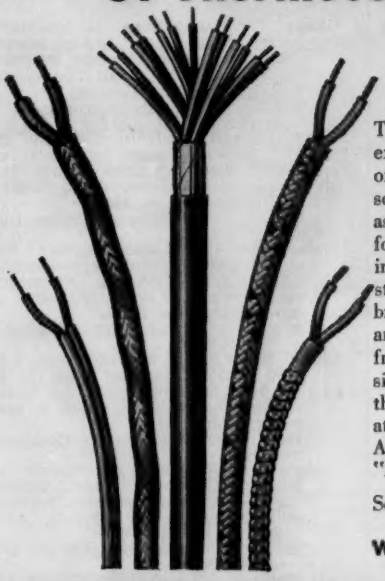

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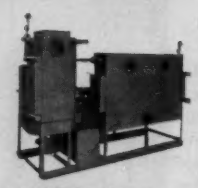

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LITERATURE . . .

Gauge.....Mastergauge is standard bearer for the broad line of Marsh Gauges for every service. Feature "Conoweld" leak-proof, one-piece tubing & socket. Catalog.
T232 *Marsh Instrument Co.

Gauges.....A complete catalogue on high pressure gauges for use in refineries and chemical plants. Information on Gauge Cock, Heated or Cooled Gauges, etc.
L190 *Strahman Valves, Inc.

Instruments.....Wide choice for measurement, recording, automatic control & telemetering. Electronic and pneumatic types. Full-size & miniature types. Data.
26 *The Bristol Company

Liquid Meter.....Capacities from 2 to 1000 gpm. in bronze; from 20 to 100 gpm. in stainless steel. A Meter Application Bulletin 566-A is now being offered.
186 *Neptune Meter Company

Meters.....Complete description of Niagara Chemical Meters, including High Pressure, Steam-Jacketed, and Electricontact Models, contained in Bulletin 43.
228 *Buffalo Meter Co. Inc.

pH Meter.....Data Sheet EIL 28 AM explains and illustrates Model 28 AM Industrial pH meter. Instrument is suited for running most types of potentiometric recorders.
214A Milton Roy Co.

Pneumatic Temperature Transmitter.....Type 12A weighs only 7 lbs. with its integral mounting bracket. It can be mounted anywhere . . . in any position. Bulletin 13-17.
157 *The Foxboro Co.

Pneumatic Transmitters.....give you a true primary & transmitted signal for indication of control. Bulletins 360 & 361.
109
*Manning, Maxwell & Moore, Inc.

Voltage Digitizers.....Bulletin gives completed information including costs on semi-conductor digitizer. Includes inputs, outputs, accuracy and speed chart on eight models.
214B Adage Inc.

Water Meters.....precision built and designed for heavy industrial service. All handle flows to 150° F. Descriptive literature available on request.
TL201 *Badger Meter Mfg. Co.

Pipe, Fittings, Valves

Duplex Tubes.....in such applications as chemical processing, refineries and food processing. Available in a wide variety of alloy combinations. Tube Manual offered.
41 *Bridgeport Brass Co.

Hinged Closures.....are available in sizes 2" through 42" for A.S.A. 150-lb, 300-lb. & 600-lb. service . . . in steel or alloys. Bulletin TT 956.
12-13
*Tube Turns Div. of Chemetron

Pipe.....Tempron non-metallic pipe for hot chemicals to 275 F. Also handles tough organics. Rigid tough nitrile. Pipe & fittings to 8". Bul. 96A.
189a *American Hard Rubber Co.

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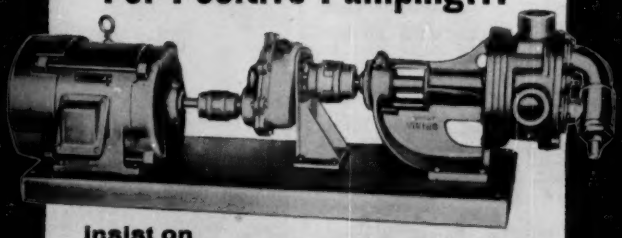

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In your own best interests, insist upon Vikings, the **POSITIVE DISPLACEMENT** pumps. Using them, you can eliminate slow priming, vapor locks, spasmodic delivery and partial emptying of tanks. Units feature the new helical gear drive and are equipped with heavy-duty pumps which deliver from 17 to 164 gallons per minute.

Five interchangeable speed reducers permit easy change of pump speeds for handling thick or thin liquids. Maximum pressure is 200 PSI on lubricating liquids, 100 PSI on non-lubricating liquids.

For complete information, send for catalog CC, pages 27-28.

VIKING PUMP COMPANY

Cedar Falls, Iowa, U. S. A. • In Canada, It's "ROTO-KING" Pumps

See Our Unit in Chemical Engineering Catalog.

Highly Intimate Blends in 1 to 2 Minutes

Blends while discharging; No segregation or flotation

Sturtevant Rotary Blenders start 4-way blending while charging, continue it during discharge, thus producing highly intimate, even blends of dry and semi-dry materials – within 3 to 5 minutes of start of charging.

Six *complete* blending cycles per hour are common. And Sturtevant's special action produces no particle reduction, cleavage or attritional heat – is highly effective yet gentle and safe even with explosives.

Receiving

Scoops cascade material as drum rotates. Movement forces material from both ends to middle. Thus blending is 4-way right from start of charging.

Discharging

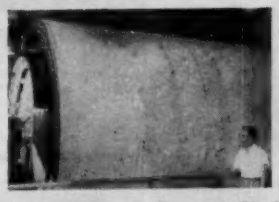
Single gate controls charge, discharge. Blending continues throughout discharge phase. Result is no segregation or flotation — highly intimate, even blends.

Self-cleaning, dust-sealed drum; one-man accessibility

Operation of Sturtevant Blenders is self-cleaning – drum interiors are completely dust-sealed. For inspection of all models, one man simply loosens a few lugs to remove manhole cover – quickly and easily.

Nine standard models with capacities to 900 cu. ft.

10 cu. ft. Sturtevant Blender at U.S. Steel Corp.'s new Applied Research Laboratory (Raw Materials Division) in Monroeville, Pa. This unit handles batches up to 500 lbs. — is ideal for pilot work and small runs.



One of four 450 cu. ft. Sturtevant Blenders at Celriver Plant of Celanese Corp. (Rock Hill, N. C.). These large units handle up to 20,000 lbs. batches — have a 9-year record of meeting the most exacting blending requirements.

Fully or semi-automatic, or manually controlled operation

Constructed of carbon steel, stainless steel or Monel metal, Sturtevant Rotary Blenders are engineered to fit each customer's needs – can be supplied with injector sprays and any desired control system.

For more on Sturtevant Blenders, request Bulletin No. 080B. (Bulletins also available on Mixers, Air Separators, Micronizers, Crushers and Grinders.) Write today. STURTEVANT MILL CO., 100 Clayton St., Boston, Mass.

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . .
(*"Income Quotient")

Design Economics of Heat Exchangers Furnish Basis for Heat Transfer Cost Engineering

The application of cost engineering practices in the accurate evaluation of capital equipment in the process industries is rapidly becoming more and more vital to the management of process companies, as margins of profit grow narrower.

Management now depends increasingly, therefore, on modern cost-engineering practices to evaluate realistically the true, long-range economy of a given piece of equipment in relation to its initial cost, cost of installation, maintenance, operation, labor, replacement — and in relation to the productivity or profit of the process involved.

The importance of efficient, practical, long-range forecasting is increasingly a focal point in the process industries as a whole, but no where is it more important than in the purchase and operation of heat exchangers for use in continuous flow processes, where the operation of the unit never ceases, and therefore must be calculated on a basis of maximum longevity, efficiency and service. Included in the design of each heat exchanger must be a consideration of its initial cost, its cost of installation (including piping, fittings, valves, flanges, etc.), its operation and maintenance (including corrosion-protection, mechanical maintenance, cleaning, re-tubing, replacement parts) — and the factor of labor costs attendant to the installation, operation, maintenance and/or replacement of the unit.

In each case, however, the basic factors must be considered and determined: capital, overhead, maintenance and unit process costs.

The Cost Engineer, therefore, must be committed to continual study, re-examination and revaluation of every area which contributes to the practice of chemical engineering, for it is from his fundamental and technical knowledge of the process involved that his eventual forecasts for productivity, efficiency and longevity must ultimately spring.

Considerable thought has been given to the "ideal" background or qualifications for the Cost Engineer. Certainly his primary requisite must be a thorough knowledge of chemical engineering, including, in the heat transfer field, an equally intimate grasp of the thermal and metallurgical engineering so vital to an understanding of heat exchanger design economics.

Secondly, he should have had practical experience in the production phases of the chemical business. Thirdly, he will be better equipped to understand the complexities of the "business" side of such evaluations, if he has had education and/or experience in a certain amount of business administration.

Clear, concise, understandable communications is another factor of great importance to the ultimate success of the Cost Engineer, for he must transmit his findings, make his recommendations and defend his decisions to a number of widely varied types of people, some with technical background and others with little or no technical knowledge.

The Cost Engineer must be tireless on detail, inquisitive at each point, yet tactful in his demands on subordinates and associates. Above all, although cost engineering presents a real challenge to his analytical mind, he must serve his purpose with genuine humility, cognizant of the amount he has yet to learn.

In short, he should have a proclivity towards the functions of management, for that is where he might very well be headed.

(FOOTNOTE: For more detailed information on this subject, write for your free copy of "Cost Engineering" to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and for immediate assistance on heat transfer cost engineering, feel free to suggest our services . . . whether or not there's a heat exchanger in your company's future!

LITERATURE . . .

Pipe.....Saran lined pipe, fittings, valves & pumps are available for systems operating from vacuum to 300 psi, from below zero to 200 F. Information available.
199 *Saran Lined Pipe Co.

Pipe, Plastic.....New 36-pg. Technical Handbook on PVC pipe is filled with information including flow charts & a corrosion resistance chart covering more than 160 acids.
87 *Kraloy Plastic Pipe Co., Inc.

Pipe, Steel.....available in right grade & size . . . seamless or welded. Information on Job-Matched Pipe and Fittings plus Bulletin TB-410 on request.
108 *The Babcock & Wilcox Co.

Tube Fittings.....Catalog of Hi-Seal tube fittings contains data, charts, laboratory tests, and formulae on corrosion, vibration, temperature, pressure & vacuum flow & velocity.
159 *Imperial Brass Mfg. Co.

Tubing.....Ace-Flex is non-toxic, odorless, tasteless, sterilizable, flexible tubing. Excellent for chemicals, foods, and for lab or machine lines. Bul. 66.
189b *American Hard Rubber Co.

Valve.....New Type G Sleeveline is a non-lubricated plug valve. For sulfuric acid service, caustic service, solvent handling, etc. Bulletin V/12. sent on request.
161 *The Duriron Company, Inc.

Valve, Ball.....Flo Ball valves are available for off-the-shelf delivery to standard ASA dimensions in semi-steel, carbon steel, stainless steel & aluminum. Information.
59 *Hydromatics, Inc.

Valve, Check.....In field service in a wide range of water, gas, air and oil applications. Techno-checks exclusive design eliminates valve seats. Information.
BR230 *Techno Corp.

Valve In-Line.....Operating method of this ⅛" in-line valve can be changed easily in the field without extra parts. Complete details.
*George W. Dahl Company, Inc.

Valve, Lubricated Plug.....are lubricant sealed against leakage. Details on all types and ratings of Lubricated Plug Valves are available.
16 *Walworth

Valves.....Nine new flanged & forged steel Gate, Globe & Check valves with hard faced seats are available. Interchangeable parts. Literature offered.
147 *Henry Vogt Machine Co.

Valves.....Feature diaphragm for positive sealing and disc for positive closure. Good for corrosive, abrasive, vacuum and difficult service. Bull. 800C.
BL201 *W. S. Rockwell Company

Valves.....Line Blind feature absolute line shut-off. Removes fire hazard of sparking & stops damage to equipment. Plug valves are perfect for hard-to-hold fluids. Catalog.
211 *Hammer Valves

Valves.....Bulletin features application & specification details on TA series Glove & Angle Valves. Lists over 100 different fluids that can be controlled by TA series valves.
R217a *The Bastion-Blessing Co.

*From advertisement, this issue

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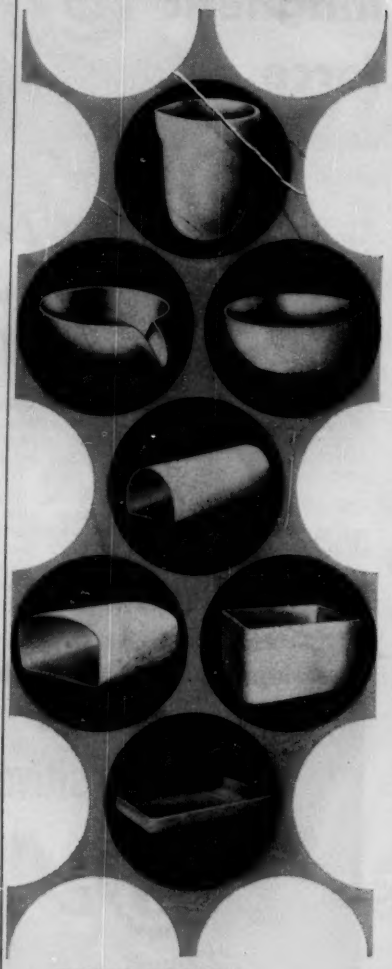
PURE FUSED QUARTZ



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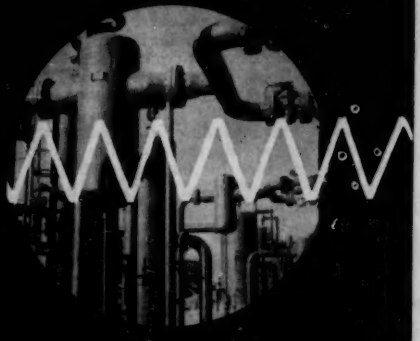

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Valves, Control.....The many special advantages of control valves are described in an informative new booklet, "What's in it for you?" Copies available.
6-7 *Minneapolis-Honeywell

Valves, Gate.....are offered in sizes, type & metals for all kinds of normal or unusual services. Catalog No. 57 is offered plus special Engineering Service.
192 *Darling Valve & Mfg. Co.

Valves, Lubricated Plug.....are available in rectangular, round, diamond & V ports; venturi, multi-port & steam-jacketed models. Sizes ½" through 30". Catalog 400.
4 *W-K-M Div. of ACF Industries

Valves, Plastic.....Revised edition of Handbook No. 1159 includes three new plastic products; 3-way valve, foot valve, & Dri-Seal No. 5. Illustrations & specifications.
217A Chemtrol

Valves, Rotary.....Types and sizes cover virtually every need . . . including Rotovalve units, butterfly & wafer valves & ball valves. Information on request.
49 *Allis-Chalmers

Valves, Solenoid.....of forged brass or stainless steel, in ⅛" & ¼" NPT size or JIC tube ends. There's a variety of AC and DC voltages. Bulletin SV-1159.
183a *Hoke, Inc.

Vibration Tamers.....New AllFlex vibration tamers for effective pipeline vibration control. Prevents cracked walls. Fact-filled data sheets available.
B231 *Allied Metal Hose Co.

Process Equipment

Air Equipment.....Bulletin No. 712 contains information on Aftercoolers and Separators. Bulletin No. 117 covers Poro-Stone Air Filters. They help provide good air supply.
R218 *R. P. Adams Co., Inc.

Blenders.....Blends while discharging; no segregation or flotation. Six complete blending cycles per hour are common. More details on blenders in Bulletin No. 080B.
R215 *Sturtevant Mill Co.

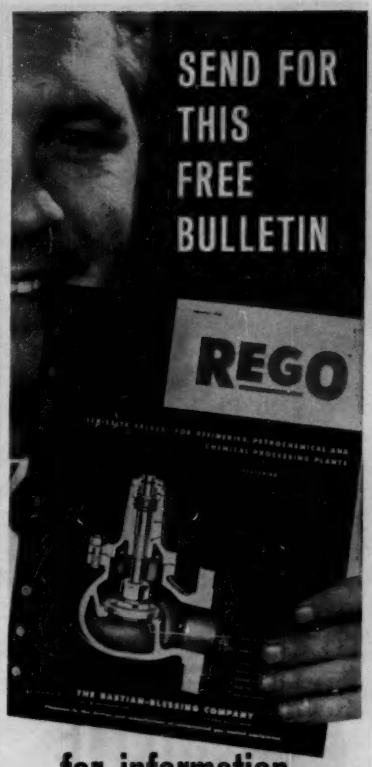
Centrifugal Separator.....Operating principles and photomicrographs of several materials handled shown in 4-page pamphlet.
Baker Perkins Chem. Mach. Div.
217B

Centrifugals.....Reduces exposure time to maintain product stability in centrifugal extractor operations. Low, compact design.
197 *American Machine and Metals, Inc.

Compressor.....24-page bulletin includes specifications on three basic models of the semi-radially constructed units ranging from 1385 cfm to 1948 cfm at 125 psi.
217C Joy Manufacturing Co.

Drying Equipment.....New catalog No. 201 contains detailed descriptions of the complete line of Drying Equipment. It is available on request.
188 *J. P. Devine Mfg. Co.

*From advertisement, this issue



for information on improved valve performance

Features application and specification details for outstanding TA Series Globe and Angle Valves. Permanently leakproof – no packing to adjust or cause binding of stems: have exclusive Teflon V-Ring Pressure Seal, providing positive leakproof stem seal; Teflon Seat Disc for long life. Rugged Ductile Iron body. Bulletin lists over 100 different fluids that can be controlled by TA Series Valves.

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FREE LITERATURE

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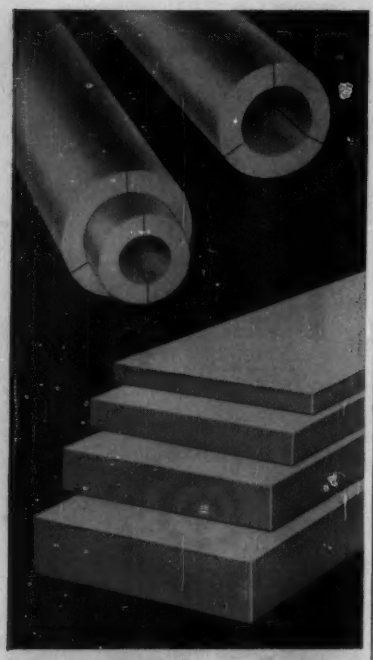
The Bastian-Blessing Company
4201 Peterson Avenue
Chicago 46, Illinois

- ☐ TA Series Globe and Angle Valves
- ☐ Relief Valve Manifolds
- ☐ Liquid Oxygen Relief Valves
- ☐ High Pressure Gas Regulators
- ☐ High Pressure Cylinder Manifolds



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LITERATURE . . .

Dust Filters.....The new "Roll-Clean" Dynaclone gives: continuous cleaning, constant suction & complete accessibility in the least possible space. Catalog 104.
193 *The W. W. Sly Mfg. Co.

Filter.....Details on the Model HR which features horizontal plate cake stability plus dry cake discharge . . . all automatic. Available now on request.
32 *Sparkler Mfg. Co.

Filter.....A complete line of vacuum and pressure filters plus all gravity and flotation equipment for liquid-solids separation. Bulletin F-2049 available on request.
Cover *Elmco Corp.

Filters.....New filter cuts filtering time in half, reduces labor costs and saves on floor space. More information on custom engineered filters in Bulletin NC-457.
196 *American Machine and Metals, Inc.

Filters.....Full-range type & size availability assures you of maximum suitability of equipment. Designed for automatic or semi-automatic operation. Bul. F-2049.
Cover *The Elmco Corp.

Filtration.....This virtually 100% pure cellulose offers more advantages as a filter medium in many food processing applications. Easy and economical to use. Facts.
205 *Brown Company

Gas Scrubbers and Cyclones.....Bulletin discusses economical control of fumes and dusts. Contains construction and operation information with data.
218A Schutte and Koerting Co.

Glassed-Steel Reactors.....Installation, operation and maintenance procedures given in 12-page manual. Contains information on proper gasketing, and repairs.
218B The Pfaudler Co.

Lubricator.....Deliver just the right amount of oil to bearings, cylinders, and packings. Unaffected by high steam, gas or air pressure. Catalog available.
212 *Houdaille Industries, Inc.

Mill, Vertical.....offers wide application to a great variety of chemicals, pigments, food products, etc. Bul. #78 gives detailed information on superfine pulverizing.
110 *Combustion Engineering Inc.

Mills, Hammer.....feature extra heavy manganese steel liners & breaker plates, oversize shafts, massive parts & reinforcements. Catalog is available.
46 *Williams Patent Crusher

Mills.....The Pebble & Ball Mills are available in a complete range of sizes from 40 to 13,000 lb. capacities, for dry or wet grinding, mixing or blending. Cat. 77.
R219 *Abbe Engineering Co.

Mixer.....The Turbulizer solves many dispersion problems in the chemical and food industries. Features inlet nozzles for adding liquids, heavy duty outboard bearings, etc.
83 *The Strong Scott Mfg. Co.

Mixer Settler Unit.....Design of a compact mixer settler unit used in solvent extraction process is discussed in bulletin. Unit is illustrated in both plan and profile.
218c Denver Equipment Co.

*From advertisement, this issue

ADAMS FACT FILE #3

INSTRUMENT AIR

Clean Dry Air Supply Will Reduce Production Down-Time . . . Instrument Maintenance . . .

Wet, dirty compressed air has no place in the process industries. In instrument air supply lines it can cause havoc. Whether it be motor air in a control circuit or supply air to the control panel, absolutely clean dry air is vital. Moisture elimination is the major consideration in providing suitable air for instrument and control systems.

Since most plant compressors in use today are oil lubricated, a finite amount of oil is present with the water vapor in the discharge. This carry-over condenses as an oil-water emulsion which often causes serious fouling of instrument components. To eliminate this oil-moisture condensate in the air lines, it is necessary to remove it before it reaches the distribution system. This is done by cooling the air before the receiver. It is advisable to cool well below the ambient conditions to provide the lowest possible humidity at the instrument panel or control units.

Two Stage System Design for Economy

The ideal method to achieve high quality air is a two-step operation.

1—An Adams Aftercooler . . . providing 2° F. cooling . . . and Cyclone Separator installed between the compressor and receiver to remove the bulk of moisture carry-over.

2 — A chemical dryer installed down stream to provide the polishing action necessary for the desired minimum humidity.

Thus, the bulk of water . . . 90% . . . is removed by the Aftercooler-Separator using plant water for cooling. A minimum moisture load is then left to be removed by more expensive methods. Under normal circumstances, all of the oil present in the compressor discharge will be removed in the Aftercooler-Separator. Fouling of the chemical unit is then virtually eliminated.

Poro-Stone Air Filter at Panel Provides Dirt-Free Control Air . . .

In spite of the efficiency of the Adams Aftercooler and Separator, there still will be some dust and dirt present in the instrument air system. That's why it is advisable to install an Adams Poro-Stone Air Filter in the line just before the control panel.

Separation by the Adams unit is in two stages — centrifugal and diffusion. Centrifugal force throws the foreign matter to the walls of the filter body where it is trapped in slots and drained. Remaining particulate matter is removed as the air passes through the pores of the Poro-Stone element.

This final protection for your instruments will minimize control system failures and process down-time. Instrument maintenance will be sharply reduced.

Literature Will Help Air System Design

For further information on how the complete line of Adams air equipment can help you provide a foolproof instrument air supply, write today for your copy of Bulletin No. 712 on Aftercoolers and Separators and Bulletin No. 117 on Poro-Stone Air Filters to the R. P. Adams Company, Inc., 207 East Park Drive, Buffalo 17, New York.

how to give yourself the air

Some raw materials are dirt-cheap — or even air-cheap. It's a steal when you can pump in a raft of outside air and ship nitric oxide or nitric acid out the back door. Maybe you want something less lethal from your oxidation-reduction process but whatever it is, activated charcoal when used as a catalyst does the job over and over again — and at low cost, too.

how to find a silver lining

It's clouds of money back in the till when solvent vapors go back in the process. Solvent vapors can play hob with the process — and the people. One activated charcoal solvent recovery system took the contaminant out of the air, the complaint out of the employee, and put 2000 gallons of solvent back into the process daily. Are you prepared for recovery?

activated charcoal

Activated charcoal (or carbon), a hard, granular, black material, acts as a molecular sponge, purifies air, gases, liquids — recovers solvents — removes odors and impurities — does hundreds of jobs. Write for Bulletin J-102. Barnebey-Cheney, Columbus 19, Ohio.

Barnebey Cheney

LITERATURE . . .

Mixers.....New Catalog "D" gives technical data & specifications of the complete line of Mass & Paste mixers & Ribbon mixers with illustrations of equipment, etc.
219A Paul O. Abbe, Inc.

Mixers.....Complete information on Double Planetary Change Can Mixers and other types of mixing, grinding or dispersing equipment now available.
L230 *Chas. Ross & Son Co., Inc.

Mixers.....Dispersator mixers with the patented "Micro-Shear" head feature: double shearing, balanced operation at much higher speeds than conventional mixers, etc.
R187 *Premier Mill Corp.

Process Equipment.....Fact-packed folder gives complete information on each of the many services. Invaluable reference material on process equipment.
24 *Artisan Metal Products, Inc.

Process Equipment.....Complete details on CB & I-built evaporators, crystallizers and filters is available on request. Feature continuous operation, even during cleaning.
37 *Chicago Bridge & Iron Co.

Process Equipment.....Engineering catalog describes all the equipment that is available; jacketed reactors, tanks, steam-jacketed agitating type kettles, etc.
180 *Groen Mfg. Co.

Process Equipment.....A new 32-page catalog illustrating & describing colloidal mills, homogenizers, pigment mills & related equipment for various industries is offered.
219B Tri-Homo Corp.

Precipitators.....“SF” electric precipitators offer high-efficiency operation, fewer shutdowns and process interruptions. Descriptive literature offered.
206 *The Buell Engr. Co.

Pulverizer.....Mikro-Pulverizers are complete with variable drives & remote controls. Bulletin 51A has the full story of models and capacities. Send for your copy.
21 *Metals Disintegrating Co., Inc.

Purifiers.....Specification Manual 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Available on request. Send for your copy.
B232 *The V. D. Anderson Co.

Rotometers.....Bulletin gives details of materials used in manufacturing rotometers for corrosive applications. Various types of designs are illustrated and described in detail.
219C Brooks Rotameter Co.

Scrubber.....The Yerzley Scrubber has a unique principle of interphase reaction with high efficiency and compact design. A descriptive bulletin is available.
170 *John Wood

Pumps, Fans, Compressors

Air Handling System.....Illustrated brochure outlines the benefits, features and components of a Fluidizer system. Also describes Fluidizer valves.
219D The Fluidizer Company

*From advertisement, this issue

Dependable, Low Cost

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• MIXING
• BLENDING

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For quality-controlled, low cost dry or wet grinding, mixing or blending on a production basis, you'll find Abbé-Engineered Pebble and Ball Mills unequaled in production speed, operating cost and service life.

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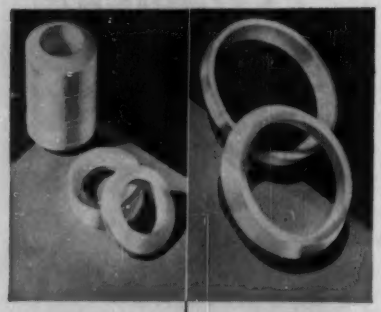
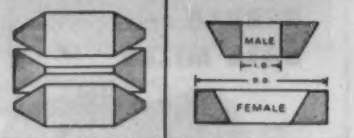
NEW CHEMPRO LOW GLAND PRESSURE TFE TEFLON† PACKING SETS





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These packings have all the advantages of Teflon, being completely unaffected by the strongest acids, solvents and alkalies.

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Resilient Chempro "Cup & Cone" or "Wedge" rings can be combined with tough, pressure-resisting Chempro Style 101 packing rings to form a rugged combination set ideal for use on a wide range of rotating or reciprocating services.

Write for revised Chempro Bulletin CP-552, giving complete ordering information.

† duPont trademark

CHEMICAL & POWER PRODUCTS, Inc.
5 Broadway, New York 4, N. Y.

LITERATURE . . .

Blowers & Gas Pumps.....for both pressure & vacuum applications. Full information about these small-capacity units, in Bulletins AF-XA-380, AF-258 and XA-458.
39 *Roots-Connersville Blower

Compressors.....from single stage to six stages, from 125 to 25,000 psi pressure for gases as follows: Acetylene, Argon, Ethane, Helium, Nitrogen, Oxygen, etc. Catalog 44.
102 *Norwalk Company, Inc.

High Pressure Equipment.....Details and specifications for measuring instruments, compressors, pumps, valves, vessels and gauges.
220A High Pressure Equipment Co. Inc.

Industrial Fans.....for material handling, stringy materials, exhaust, circulation. Remove metal dust, chips, etc. Convey long fibrous materials. Handle air, gases, etc.
85 *Westinghouse Electric Corp.

Pumps.....Fig. 3405 medium-size pump provides giant-size capacity: 6400 gallons per minute. Heads go up to 425 feet. Additional data on request. Bul. 721.6.
95 *Goulds Pumps, Inc.

Pumps.....Literature is available on products for handling corrosive & hazardous processing fluids such as; All-Chem rotary pumps, Gearchem gear pumps, etc.
91-92 *ECO Engineering Co.

Pumps.....Heavy duty process pumps adapted for handling fluids with solids in suspension, slimes and slurries in temperatures to 350F and pressures to 400 lbs.
220B Goulds Pumps, Inc.

Pumps....."Karbate" impervious graphite pumps are resistant to mineral acids, acid combinations, and organic and inorganic compounds of all types. Literature.
23 *National Carbon Co.

Pumps, Centrifugal.....Type CK is a heavy duty, low speed solids pump designed to handle fluids containing random size solids & heavily abrasive materials. Details.
98 *Morris Machine Works

Pumps, Centrifugal.....Bul. P-300 outlines & illustrates the new design of the stainless, foamless, sanitary centrifugal pumps. Capacity & Head Selection Table too.
220C Waukesha Foundry Sales Corp.

Pumps, Chemical Feed.....New 300 Series Simplex model can pump up to 812 gph. Duplex model has double this capacity. Maximum pressure of 10,000 psi. Information.
178 *American Meter Co.

Pumps, Leakproof.....Technical Bulletin #4 enumerates application of sealless pumps in the nuclear field. Includes information on temperature and pressure, corrosion, maintenance.
220D Chempump Div., Fostoria Corp.

Pumps, Rotary.....Eliminate slow priming, vapor locks, spasmodic delivery and partial emptying of tanks. Complete information in Catalog CC, pages 27-28.
BL215 *Viking Pump Company

Pump, Slurry.....Bulletin describes Oliver diaphragm slurry pump capable of metering slurries with up to 60% solids at controlled volume accuracy of ±2.0%. Specifications.
220E Milton Roy Co.

*From advertisement, this issue

You make test after test after test with complete accuracy because **TAYLOR COMPARATORS** have guaranteed non-fading color standards

FAST, EASY TESTS FOR pH, CHLORINE, PHOSPHATE

WRITE FOR FREE HANDBOOK
101 pages of technical data and useful information. Gives theory and application of pH control. Describes full Taylor line.

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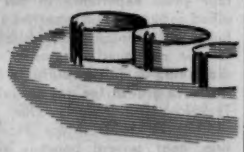
414 STEVENSON LANE • BALTIMORE 4, MD

CORROSION
PROBLEMS IN . . .

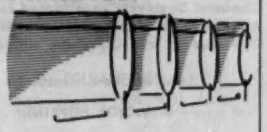
TANKS AND TANK TRAILERS?



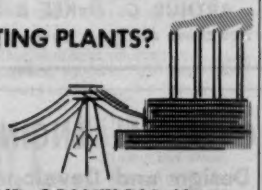
PROCESS PIPING?

STEEL AND CONCRETE IN PROCESS AREAS?

CHEMICAL SPILLAGE?



GENERATING PLANTS?



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LITERATURE . . .

Services & Miscellaneous

Acid Gold Plating Process.....New 6-page paper describes metallurgical properties, operational data, & uses of acid-type industrial gold electroplating formulation.
221A Sel-Rex Corp.

Casters & Wheels.....designed to suit your every need. New Manual contains the complete story about the many outstanding features such as rubber treads & string guards.
L187 *Darnell Corporation, Ltd.

Conversion Factors Chart.....Reference table includes conversions of inches to centimeters, cubic feet to liters, microns to meters and many other common conversions.
221B Precision Equipment Co.

Corrosion-Proof Installations.....are covered in Bul. CC-3. Includes; pickling, plating, chemical processing & storage tanks of all kinds, industrial floors, etc.
R190 *Atlas Mineral Products

Corrosion Resistance Chart.....new four page chart lists 150 chemicals and their recommended usage with ductile iron, iron, steel, stainless steel, monel, brass, bronze etc.
221C OPW-Jordan

Fluorescent Penetrant.....finds all cracks, pores, leaks in nonmagnetic materials. Illustrated bulletin includes low prices and other details sent on request.
BL213 *Magnaflux Corp.

Noise Hazards.....Pamphlet suggests ways industry can minimize noise that may contribute to hearing loss. Bulletin 207 is first in a new series on safety in industry.
221D U. S. Dept. of Labor

Safety Accessories.....24-page handbook covers full line of safety gratings, stair treads, safety edgings and step bars. Illustrations included to assist special purpose designs.
221E Bustin Steel Products Co.

Slide Rule.....Lists 22 metals and materials and their degree of resistance to 247 corrosive agents. Slide Rules are available on request. Send for yours today.
183b *Hoke, Inc.

Tool Truck.....The new Tool Truck is invaluable wherever tools or parts transport is needed. Upper panel section is partitioned for nuts, bolts, parts. Information.
171 *Snap-On Tools Corp.

Turrets.....Fire-Fighting Turrets discharge FogFoam, Solid Foam Stream, WaterFog, Solid Water Stream. Full details on the complete line of fire-fighting products.
175 *Rockwood Sprinkler Co.

Water Conditioning.....Data sheet is available on corrosion problems in industrial water systems. Explains how and why boiler, cooling and process systems are plagued.
221F Betz Laboratories, Inc.

Weathermaker System.....Rotaspray units may be installed rooftop mounted, ceiling suspended or outside wall mounted. Information offered.
48 *Carrier Corporation

*From advertisement, this issue

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Chlorine—Soda Ash—Perchlorethylene
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Several positions available for chemical engineers with 2–5 years' experience in process engineering of chemical, petrochemical or petroleum refining plants. Strength should be in the areas of unit operations, heat transfer, thermodynamics, distillation and fluid flow. Positions cover process engineering performed for sales proposals and final plant design, for operating and process improvement of existing plants as well for developmental process engineering.

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Several positions available for ChE's or ME's with 2—5 years' experience in the process industry in process, design or operations of which 2 years should be in appropriate estimating or economics experience. Duties include determination of material and equipment needs, equipment arrangements, process suitability, process or component economics or cost data. Costs estimates will cover total costs of equipment, plants or products to be sold or furnished by the company. Individual must be able to deal effectively with all engineering levels.

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Our expanding sales activity requires the addition of several ChE's or ME's to prepare technical sales proposals and economic evaluations. Responsibilities include liaison and close coordination between the Sales Departments and the Engineering, Manufacturing, Operations and Financial Department as well as top management. These positions will be filled by individuals with 0–5 years' experience in a staff sales capacity or who are currently employed in the chemical, petroleum or related industries. *Unusual and exceptional opportunities for those interested in sales engineering or sales administrative functions and responsibility.*

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Recent promotions in our Technical Department have resulted in openings for Chemical Engineers. We prefer two to four years experience in our own or allied industries but experience in other fields will definitely be considered. Due to our continued expansion, we feel that there is full opportunity for professional growth for anyone joining our Technical Department. Our plant is located in Southeastern North Carolina, near several beaches and other recreational facilities. Salary commensurate with experience and ability. Write to

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(*Additional Business Opportunity ad on page 224*)

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TITANIUM DIOXIDE PLANT
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CENT.—FILTERS—EVAPS.—CRYSTAL

1—Bird 32" x 50" Cont. Cent. 316 S.S.
4—Sharples C20 Super D-Hydrators, 316 S.S.
1—AT&M 26" sus. Cent., perf. bskt., 316 S.S.
1—Oliver 8' x 8' Precoat rubber covered Rotory Vacuum Filter.
4—Sperry 36" plate & frame Filters, rubber covered, cast iron, and wood.
5—8' dia. x 24' rubber lined Crystallizers.

PULVERIZERS AND MILLS

2—Abbe 5' x 16' brick lined Mills.
2—30' dia. Stainless Steel Micronizers complete with Hoppers, Conveyors, etc.

ROTARY KILNS

1—Traylor 11' x 155' Rotary Kiln, 7/8" shell.
1—Renn. 6' x 60' Rotary Kiln, 5/8" shell.

RUBBER LINED TANKS

5—8500 gal Vertical Storage 8'6" x 16' x 8' cons.
1—13,000 gal. Horizontal Storage 8' x 35'.

STEEL TANKS

6—2000 to 5200 gal. with Turbo Agitators.
14—Storage Tanks: 3800; 6000; 9000; 10,000; 15,000; 47,000 gals.

MISCELLANEOUS

7—Dorr Thickener[illegible]6' dia. with Tanks.
1—Bemis 50# Bag Packer with Sewing Machine, Conveyor and Flattener.
50—LaBour, Durco, Worthite, Duriron and Stainless Steel Centrifugal Pumps 2" to 6" with motors.

Representatives on premises,
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Telephone: Medford 3-2911

BRILL EQUIPMENT CO.
35-65 Jabez Street,
Newark 5, N. J.
Tel: Market 3-7420

CIRCLE B ON READER SERVICE CARD

OIL REFINERY

DESTREHAN, LA.

Partial List

5—B & W 70,000#/hr. Boilers, 450 psi. (1952)

3—Carrier Centrifugal Compressors; 38, 300, 9370 and 5535 cfm.

87—Heat Exchangers, 50 to 6000 sq. ft., steel and Adm.

15—Pressure Vessels, 3' to 23' dia.

125—Centrifugal Pumps, XP motor & turbine drives, up to 9000 gpm.

10—Steel Bubble Cap Towers, 2' to 12' dia., up to 109' high.

54—Storage Tanks, 1000 to 80,000 barrels.

6—Hortonspheres, 5000 to 10,000 barrels.

LIST AVAILABLE ON REQUEST
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Site Office, Destrehan, La.
Phone NORCO 6571

CIRCLE C ON READER SERVICE CARD

BUY BRILL

REACTORS—EVAPS—CONDS—TANKS

1—Condenser Service 650 gal. 304 S.S. closed, kettle, 5' x 4', with 100 sq. ft bayonet heater.
1—1400 gal. Blaw-Knox, steel jacketed, agitated Reactor.
2—2000 gal. Struthers Wells 316 S.S. jacketed, agtd. Reactors.
2—3200 gal. 304 S.S., jacketed, agitated Kettles.
1—550 sq. ft. Buflovak, monel single effect Evaporator.
1—Baker Perkins 700 gal. jacketed, agitated Dissolver.
1—7500 gal. 316 S.S. Vert. Storage Tank, 7' x 25', 50 psi.
1—750 gal. nickel clad Mixing Tank, 125# nickel coils.
1—4000 gal. Haveg Vert. Tank 8' x 12'.
1—1500 gal. Stainless Pressure Tank, 5' x 10', 90#.
1—12000 gal. horiz. steel Pressure Tank, 7'6" x 36", 200 psi.
1—17,850 gal. 304 S.S. Storage Tank, 9' x 36'.
6—Stainless Heat Exchangers; 1220, 786, 536, 396, 315, 250 sq. ft.
1—24" dia. x 25', 304 S.S. Bubble Cap Column.
1—30" dia. x 20', 304 S.S. Bubble Cap Column.

CENTRIFUGES

1—Sharples C-27 Super-D-Hydrator, 316 S.S.
1—Bird 18" x 28", 316 S.S. Solid Bowl, Continuous.
1—Bird 18" x 28" steel, Solid Bowl, NEW, Continuous.
1—Bird 36" x 50", 347 S.S. Solid Bowl, Continuous.
2—Sharples PY14, PN14, Super-D-Canters, 316 S.S.
1—Tolhurst 32" Suspended, 316 S.S., imperforate basket.
2—AT&M 48" Suspended, 316 S.S. basket.
2—Sharples #16, 304 S.S., 3 HP motor.

MIXERS

1—#12 Sturtevant 304 S.S. Rotary Mixer, 450 cu. ft.
1—Baker, Perkins #16TRM, 150 gal. jktd., Vac. 60 HP
5—Day "Cincinnatus" double arm, 250 and 100 gal.
1—1500# Powder Mixer, 7½ HP XP Motor.
2—Steel, jktd. Powder Mixers, 225 and 350 cu. ft.
1—36" dia. Simpson Intensive Mixer.

DRYERS

3—Buflovak Vacuum Shelf, 20-60" x 80" shelves.
1—Devine Vacuum Shelf with 19—59" x 78" shelves.
1—Devine Vacuum Shelf with 1C—40" x 43" shelves.
2—Buflovak 42" x 120", atmospheric, double drum.
2—Devine, 4' x 9', single drum, atmospheric.
1—Baker Perkins 5'6 x 6' Rotary Vacuum Dryer.
1—Buflovak 3' x 20' Rotary Vacuum Dryer, 316 S.S. Unused.
1—Louisville 54" x 35', Monel Rotary Steam Tube Dryer.
2—Louisville Rotary Steam Tube 6' x 25', 6' x 50'.
9—Rotary Dryers, 34" x 30', 4' x 40', 6' x 50', 6' x 60' 7' x 80', 8' x 87'.
2—Louisville 8' x 50' Stainless Steel lined Rotary Dryers.
1—Traylor 30" x 18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5" x 25", 6'4" x 24', SS Louvre Dryers.

FILTERS

1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 3' x 6' Steel Rotary Vac. Precoat Filter.
1—Niagara #370-38 Filter, 370 sq. ft., 304 S.S.
2—#49 Vallez Rotating Pressure Filters, 738 sq. ft.
1—Oliver 5'3" x 8' Steel Rotary Vacuum, vaporite housing.
1—Sparkler, 33S28 Filter, 150 sq. ft., 304 S.S.
2—Sparkler, 18D8 Filter, 12.3 sq. ft., 304 S.S.
1—Feinc 5' x 6' Stainless Steel Rotary Vacuum Filter.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

MISCELLANEOUS

1—Hpm 88 ton horizontal Steeping Pres.
1—Ross 6" x 14" Three Roll Mill.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—Robinson Sifters, 40" x 84", Stainless.
3—Robinson Gyratory Sifters, 30" x 104", Quadruple Deck.
8—Stokes; DD2, DDS-2, T, "R", and "F" Tablet Presses.
4—Nash Vacuum Pumps; H6, TS7, #2.
25—Chlorimet, Durimet and Duriron Centrifugal Pumps, 1½" to 6".

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Patterson 6' x 8' Porax Lined Pebble Mill. 20 HP expl. proof Motor
Alco Products 735 sq ft type 316 S.S. Heat Exchanger, 200-1" O D tubes 16'
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ROTARY DRYERS—24" x 22'—36" x 24'—44" x 25'—8' x 50' (2) all w/motor drives—burners/blowers avail.

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1—500 gal. Pfaudler G. L. jacketed and agitated reactor.
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304 or 316 S. S. CONSTRUCTION
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3—New 25 Ton, 2 GE I Whitcomb
3—23 Ton, 2-45 Ton Used Gen. Elec.
1—44 Ton, 1-80 Ton Used Gen. Elec.
1—100 Ton, Alco Used, New 1955.
3—100 Ton, Gen. Motors, Used.
1—25 Ton, Industrial 60' Boom Loco. Crane.

PLANT EQUIPMENT

2—Wemco 2M-HMS-Plants.
36 x 42 Jeffrey Hammermill, Type B-2.
2—5' x 30" Hardinge Ball Mills.
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2—Buchanan 13" x 24" jaw crushers, 50 HP

1—Pangborn dust collector and 15 HP exhauster

1—Dings Magnetic Separator

2—Symons 3' shorthead cone crushers, fine bowl

1—Christie 4'-6" x 45' long rotary spar dryer, complete

1—Allis-Chalmers 6' x 18' pebble mill, buhrstone lined

5—Bucket elevators, up to 40' high, on rubber belts

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1—17,650 gal., horiz., T316 SS, 9' x 36', ¼" shell, ⅜" dished heads, 40# WP.

1—10,000 gal., horiz., T304 SS, 8' x 26', cone heads.

1—3700 gal., vert., T304 SS, 6' x 17', VACUUM, int. coils.

1—3400 gal., horiz., T304 SS, 6'6" x 16', ¼" shell, 7/16" dished heads.

1—3300 gal., vert., T304, SS, 8' x 14'6", ⅜" shell, ⅜" heads, 70# WP.

1—2830 gal., horiz., T316 SS, 6' x 12', 5/16" shell & dished heads, VACUUM

3—2750 gal. vert., T316 SS, 7' x 8' dished heads, 50# WP. 75 sq. ft. coil.

6—2600 gal. vert., T316 SS, 7' x 8', flat bottom, 19# WP, 5 HP agit.

1—2500 gal., vert., T316 SS, 7' x 7', ¼" shell, 5/16" dished heads, 70# WP.

6—2250 gal., vert., T316 SS, 7' x 6'3", dished heads, 70# WP, 5 HP agit.

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12—1750 gal., vert. hoppers, T304 SS, double cone bottom.

4—1200 gal., vert., T316 SS, 5' x 7', cone bottom, VACUUM.

1—1,000 gal. vert., T316 SS, 5' x 7', ¼" dished heads.

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1—110" dia. Vulcan—10 trays

2—96" dia. Vulcan—30 trays

1—96" dia. Vulcan—10 trays

2—60" dia. Vulcan—10 trays

1—48" dia. Vulcan—25 trays—T304 ELC

1—42" dia. Vulcan—Packed—32' high

1—36" dia. Vulcan—6 trays

1—24" dia.—Packed—28' high, T304

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1—1960 sq. ft., T316 SS exchanger

8—800 sq. ft., T316 SS condensers

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25—Copper & Cupro-nickel exchangers & condensers, up to 1070 sq ft.

FILTERS—CENTRIFUGALS

1—Niagara #510-28, 510 sq. ft. vert. leaf, T316 SS.

1—Alco 110 sq. ft., T316 vert. filter.

1—Sparkler #33-S-28, 151 sq. ft. horiz. plate, T304 SS.

1—Elmco 18" dia. x 24" face T304 SS rotary vacuum

2—Oliver 5'3" dia. x 3' face rot. vac., pressure precoat, T316 SS, ASME 30# pressure housing.

1—Oliver 5'3" dia. x 8' face rot. vac., precoat, steel. UNUSED.

8—Sharples #AS-16V super cent. Inconel, Vapor-tite.

2—Sharples #16P, T304 SS pressure-tite centrifugals.

3—Sharples #C-20 Super-D-Hydrators, T316 SS.

2—Bird 18" x 28" horiz. cent., T304 SS.

1—Bird 32" x 50" horiz. cent., T316 SS.

2—Sperry 30" P. & F. filter presses, 18-9 st. st. (NI-RESIST).

BEST BUYS

1—Kennedy Van Saun 7' x 9' contin. ball mill—150 HP.

12—4500 gal. nickel-clad tanks, 8' dia. x 11' high, cone bottom, 125# WP.

1—Struthers-Wells 630 sq. ft. T316 SS evaporator.

3—18,000 gal. Aluminum cone-bottom tanks, 12' dia. x 31' OAH.

1—Link-Belt #604-18 roto-louvre dryer, cyclone, fan, etc.

3—Worthington 160 ton steam-jet vacuum refrig. units.

2—Buffalo T316 SS Blowers, 2330 cfm, 60 HP TEFC. Motor.

2—1800 cu. ft. Read T304 SS weigh hoppers, with scales, T304 SS screw conveyor, bucket elevators, AJAX "Le-veyor" shaker conveyors.

1—Vulcan 10' x 11' x 175' long rotary kiln, 13/16" shell, 2-tire.

1—Bartlett & Snow 3' x 15' everdur rotary dryer.

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GELB

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1—18,000 gal. type 316 SS pressure tank, 60 psi
1—Eimco type 316 SS rotary vacuum drum filter, 3' x 1', complete
5—Pfaudler Series XL 1000 gal. glass lined jacketed reactors, complete with drives and anchor type agitators.
3—Struthers Wells type 316 SS jacketed reactors, 2000 gal. with agitators and drives, 40# internal pressure

AUTOCLAVES, KETTLES AND REACTORS

1—Aluminum 16,000 gal. horiz. storage tank
1—Type 316 SS 2000 gal. horizontal tank
1—Edgemoor type 316 SS 750 gal. jacketed reactor
1—Pfaudler Series EL, glass lined jacketed reactor, 300 gal. complete with anchor type agitator and drive
2—Pfaudler 200 gal. glass lined jacketed, reactors complete with anchor type agitators and drives
1—Pfaudler 100 gal. glass lined jacketed reactor, complete with anchor type agitator and drive
1—Pfaudler 100 gal. glass lined vacuum receiver
1—Steel and Alloy Tank Co. 100 gal. type 347 SS pressure tank, 250 psi jacket
1—Blaw Knox 400 gal. steel jacketed autoclave, 370# internal pressure, 85# jacket
1—Blaw-Knox 45 gal. jacketed autoclave, 1500# pressure
1—Paterson Kelley 6000 gal. steel jacketed kettle

DRYERS

3—Link Belt steel roto louvre dryers, Model 207-10, 310-16, 604-20
1—Buflovak stainless steel rotary vacuum dryer, 3' x 15'
1—Stokes Model 58DS steel rotary vacuum dryer, 5' x 30'
2—Louisville rotary dryers, 8' x 50', SS
1—Louisville rotary steam tube dryer, 8' x 45'
1—Louisville rotary dryer, 38" x 40', Type L
1—Traylor 4' x 40' rotary dryer
1—Rotary dryer, 6' x 36'
2—Stokes Model 138J-20 single door vacuum shelf dryer, 20 shelves, complete
1—Western Precipitation Corp. SS pilot spray dryer, Type N-2
4—Gordon single truck tray dryer

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
1—Sweetland #3 stainless steel filter
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver SS rotary pressure precoat filter, 5'3" x 8'
1—Oliver horizontal filter, 3'
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers
1—Shriver C. I. plate and frame filter press, 36" x 36", closed delivery, 4 eye, 60 chambers

CENTRIFUGES

1—AT&M 26" suspended type centrifuge with SS perforated basket, complete with plow and motor
1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforated basket

THE GELB GIRL—MARCH 1960

2—Fletcher 40" center slung rubber covered centrifuges with perforated baskets and motors
1—AT&M 40" SS suspended type centrifuge, complete with motor and plow with perforated basket

MIXERS

15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Baker Perkins size 16 type TRM, 150 gal., jacketed double arm sigma blade mixer with vacuum cover
3—Robinson type 316 SS sigma blade jacketed h.d. mixers, 400 gal.
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixers with double naben blades
1—Entoleter impact mill type PPM-27
1—Stokes SS granulating mixer, Model 21-J
3—Banbury #1 mixers, chrome plated rotors, with 50 HP motors
1—Baker Perkins size 16, type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor

MISCELLANEOUS

1—Cleaver Brooks 500 HP package steam generator, 200#
1—York Shipley 175 HP package steam generator, 135# psi
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Vulcan SS bubble cap column, 4' x 28 plates
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
1—Downington type 316 SS heat exchanger, 750 sq. ft.
2—Swenson type 316 SS vacuum crystallizers, 3'6" x 12', 2' x 12'
3—Williams type 316 SS hammermills, Model AK
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14", 3 roll paint mill, complete
2—Sweco 48" SS separators, Model D-2D-8
1—Stokes stainless steel coating pan, 3' dia.
50—Steel heat exchangers, 15 sq. ft. to 100 sq. ft.
4—Stokes tablet presses, Model T and R, with drives and motors

2—Sturtevant #7 SS dust type rotary batch blenders, new
4—Tolhurst 40" center slung rubber covered centrifuges with perforated baskets and motors
1—Pfaudler Series R, 300 gal. glass lined jacketed reactor, with impeller type agitator and drive, 125# internal pressure 85# jacket
15—Davis Engr. SS heat exchangers, 145 sq. ft. (new)

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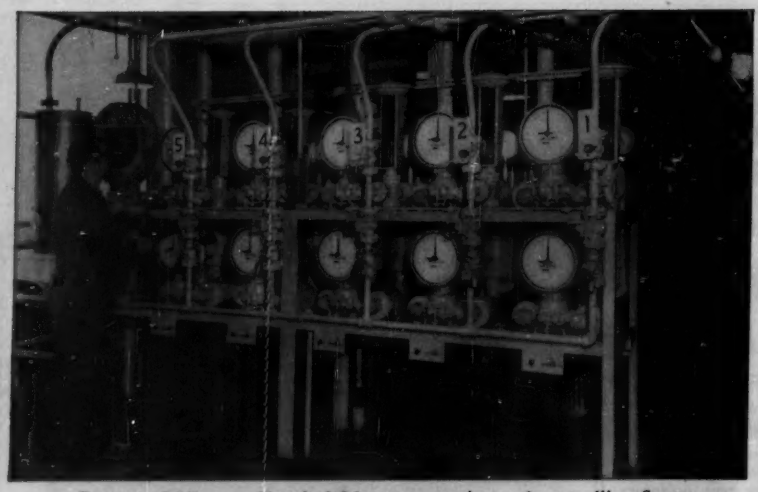

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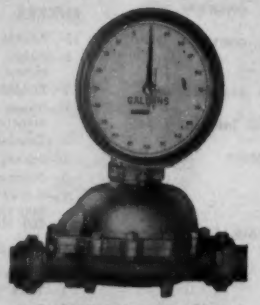

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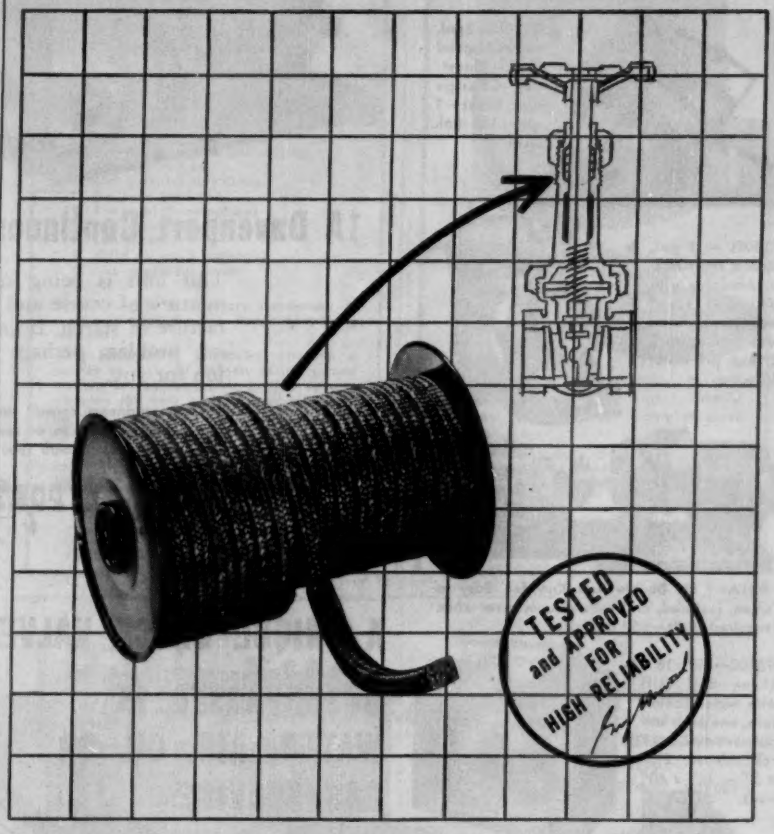

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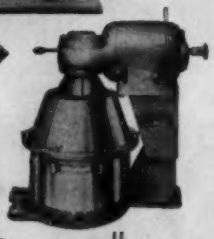

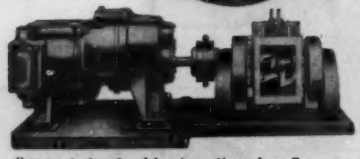

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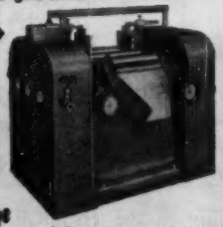

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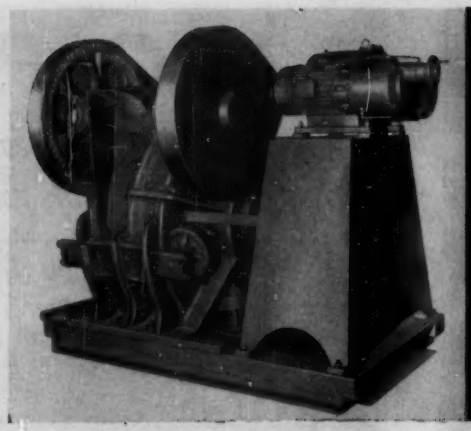

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Steel, Flanged	150	3", 4", 6", 8"
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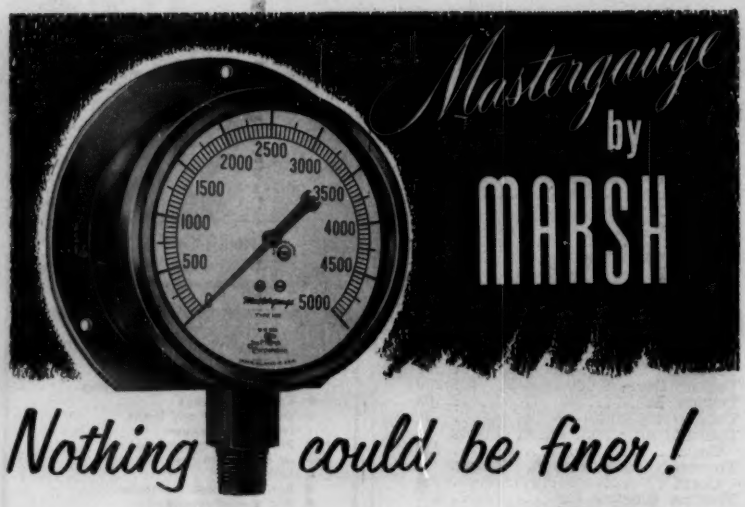

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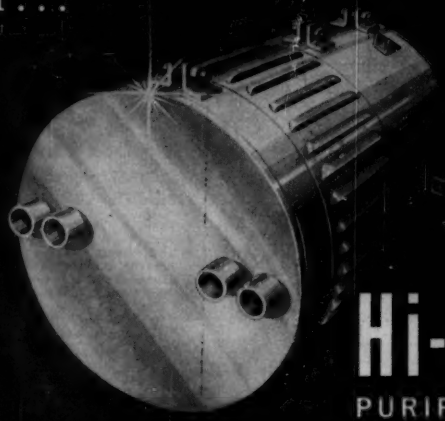

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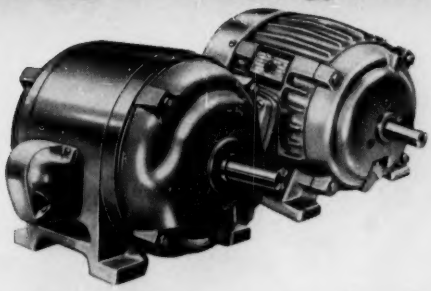

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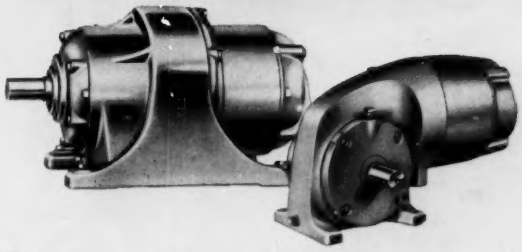

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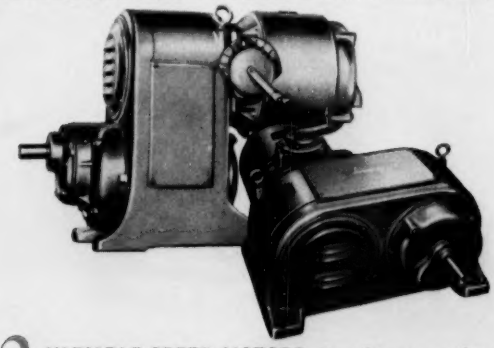
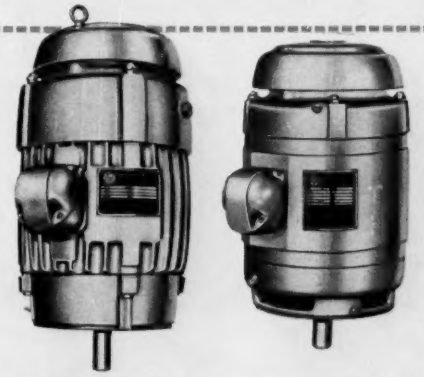


3 **VARIABLE SPEED MOTORS,** *Varidrive,* upright, ¼ to 75 h.p.; *Varidrive,* horizontal, ¼ to 60 h.p. (Other available types not shown)



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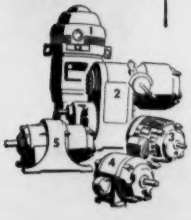

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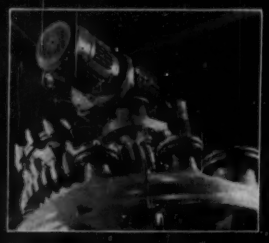
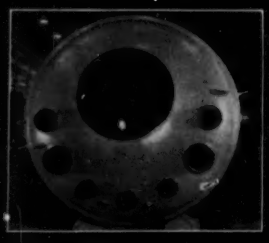
FLUIDICS* AT WORK

from top to bottom... Pfaudler "RA" Series Reactors

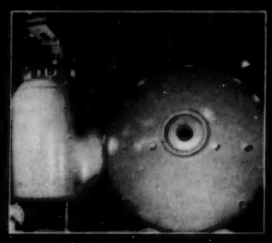


TW drive, one of two new drives, provides increased stability for agitator shaft. Runs very quietly.



"Mirror image" provides like-size nozzles on each half of top head. Facilitates piping.

Different silhouette and light-blue exterior tell you the Pfaudler "RA" Series Glasteel Reactor is new. Unit shown has BH drive.



Offset bottom head outlet is in sweep path of agitator and in line with top head manhole.

The old "Pfaudlers" (R Series) that you're so familiar with are passing from the scene.

In their place, we now offer you the all new "RA" Series Glasteel Reactors with many significant design improvements.

Two New Drives. Starting at the top you'll find the TW drive on the 300 through 1000 gallon reactors for power requirements to 15 H.P. The BH drive takes over on the 1500 gallon and larger sizes for power requirements to 60 H.P.

Both drive designs are compact, easily installed and maintained. Very quiet, too — a difference that's appreciated when operating a full line of reactors.

Mirror Image Top Head. Next, note the equal number of nozzles on each half of the top head, placed symmetrically for ample freedom in piping. For example, you can feed two reactors from a single tee—one to the left, one to the right.

And since there are no cumbersome drive supports, you have convenient access to manhole, observation window, nozzles, drives, baffles, dip pipe and mechanical seal.

Offset Drain. Off the bottom head you get fast drainage, since the outlet has been offset from center to a position in the direct sweep-path of the agitator. Also, the outlet is in line with the top head manhole for convenient inspection.

Corrosion Resistance. Of course, inside there's Glasteel 59. Excellent resistance to all acids (except HF) to 350°F. and on to 450°F., depending on concentration. Mild alkalies at moderate temperatures are also permissible. Thermal shock resistance is up 30% over the "R" series. At a vessel temperature of 250°F. your recommended safe temperature differential is now 260°F. Abrasion resistance has also been increased by 20%. Glasteel 59 is smooth —resists build-up of sticky products. As a result, you have high heat-transfer rates, increased product yield, fewer shutdowns for cleaning, and much longer service life.

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